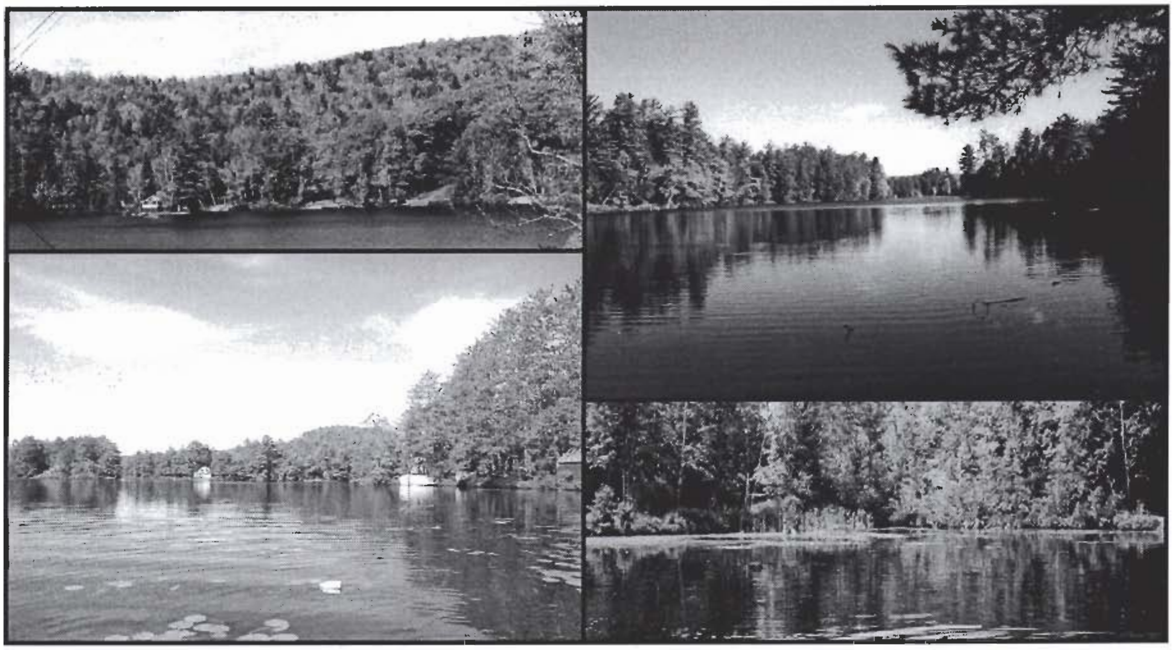
Partridge Lake
Littleton, New Hampshire



Lake and Watershed
Diagnostic Study
FINAL DRAFT COPY

Final Report
Summer 2005

NEW HAMPSHIRE
DEPARTMENT OF
Environmental Services

Partridge Lake and Watershed Diagnostic Study
DRAFT FINAL COPY

Final Report
September 2004

New Hampshire Department of Environmental Services
Water Division
Watershed Management Bureau
Biology Section
29 Hazen Drive
Concord, NH 03301
(603)271-2963
www.des.state.nh.us

Amy P. Smagula
Jody Connor
Principal Authors

Michael P. Nolin
Commissioner

Michael Walls
Assistant Commissioner

Harry T. Stewart
Division Director

Paul Currier
Watershed Management Bureau Administrator

Robert H. Estabrook
Chief Aquatic Biologist

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Page #

Chapters

Page #

Page #

Partridge Lake Report
List of Figures

Partridge Lake Report
List of Tables

List of Appendices

Appendix	Description
1	Hydrologic Budget Raw Data and Calculations
2	Nutrient Budget Raw Data and Calculations
3	Septic System Survey
4	Temperature and Oxygen Graphs
5	In-Lake and Tributary Raw Data
6	Best Management Practices
7	Minimizing the Impact of Development on Water Resources
8	Low Impact Development
9	Shoreland Protection Act: Fact Sheets and Recommended Native Plantings
10	Towns of Franklin and Deering Zoning Regulations and Overlays
11	Perched Beaches

ABSTRACT

The Partridge Lake Diagnostic Study presents twelve months of limnological data and discusses watershed water quality trends over time. The diagnostic data can be used to determine where problem areas occur in the watershed, and for information on where to focus remediation efforts.

The following tasks were completed during the study and research phases of this project:

1. Identified the historical and existing water quality of Partridge Lake;

2. Identified the water quality of Partridge Lake's inflowing tributaries, nearshore groundwater seepage, and outflow;

3. Developed estimated hydrological and phosphorus budgets for Partridge Lake;

4. Documented sources of phosphorus to the lake;

5. Compared trophic models that classified Partridge Lake;

6. Reviewed many potential non-point sources of phosphorus to the lake;

7. Recommended non-point source Best Management Practices that will help protect the lake for future generations;

8. Recommended management strategies to minimize nutrient additions to the lake, and how to protect the lake in the future.

The results and recommendations of the Partridge Lake Diagnostic Study provide a basis for lake protection through watershed management. Watershed management activities should be the immediate goals of the lake association, towns, and watershed residents.

Although this project was successful in accomplishing its goals, only upon the implementation of a watershed management program, which includes phosphorus reduction, will this project be considered a complete success.

ACKNOWLEDGEMENTS

Special thanks to the Partridge Lake volunteers for their help during the field data collection phase of this study. Volunteers dedicated time to collecting water samples, reading staff gauges, driving samples to Concord, and reporting any unusual occurrences in and around the lake. This total two-year process could not have been successful without them. Thank you all!

Partridge Lake Volunteers Included:

John Aja
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A special thank you to Dayton Goudie for his continued involvement in VLAP, his field assistance, and his dedication to this special study.

GLOSSARY OF TERMS

ALGAL BLOOM: A dense concentration of algae due to an increase of nutrients to the water body, such as phosphorus.

ANOXIC: Lack of oxygen (also, anaerobic).

AQUATIC PLANT GROWTH: The growth of plants living in a water system.

CHLOROPHYLL-a ANALYSIS: Measurement of the chlorophyll-a, which occurs in aquatic plants and algae.

COLOR: A visual measure of the water color. Decaying organic matter and metals contribute to water color.

CULTURAL EUTROPHICATION: The addition of nutrients to a water body due to human activity, including fertilizing, dumping of yard wastes, failing septic systems, and increasing impervious surfaces and runoff.

CYANOBACTERIA: The blue-green algae.

DECOMPOSITION: The breakdown of an organic substance.

DECOMPOSING BACTERIA: Bacteria which break down organic matter.

DIAGNOSTIC STUDY: An intensive and comprehensive study of a lake and its watershed.

DIMICTIC: Lakes that circulate freely twice a year in the spring and in the fall. They are directly stratified in the summer and inversely stratified in the winter.

DISSOLVED OXYGEN: The oxygen that is in solution, i.e., dissolved in the water.

EPILIMNION: The upper, well-circulated, warm layer of a thermally stratified lake.

EUTROPHIC: Nutrient rich waters, generally characterized by high levels of biological production.

EUTROPHICATION: The addition of nutrients to a water body due to the natural aging of the water body or to human activity.

HYDROLOGIC BUDGET: A compilation of the total water inputs and outputs to and from a lake.

HYPOLIMNION: The deep, cold, relatively undisturbed bottom waters of a thermally stratified lake.

IPWS: Interstitial Pore Water Sampler. This device is used to collect the water held in the pore spaces of soil.

LIMNOLOGIST: A scientist who studies freshwater ecology.

MESOTROPHIC: Waters containing an intermediate level of nutrients and biological production.

METALIMNION: The middle layer of water in a thermally stratified lake, between the epilimnion and hypolimnion, where the decrease in temperature with depth is at its greatest.

NITROGEN: A necessary nutrient for life, fixed by some bacteria and plants.

OLIGOTROPHIC: Nutrient poor waters, generally characterized by low biological production.

ORGANIC MATERIAL: Matter making up dead or living organisms.

PHOTIC ZONE: The depth of lake water that receives sufficient sunlight to permit photosynthesis.

PHYTOPLANKTON: Microscopic plant life that float within or on top of lake water.

PLANKTON: General term for plant and animal life that float within or on top of a water body (see also phytoplankton and zooplankton).

RESPIRATION: The exchange of gases, such as carbon dioxide, between a living organism and its environment.

STRATIFICATION: The layering of water due to temperature differences (see also epilimnion, hypolimnion, and metalimnion).

TRANSPARENCY: The clarity of the water, commonly measured with a Secchi disk.

TROPHIC STATUS: The degree of lake aging or nutrient status of a lake (see oligotrophic, mesotrophic, and eutrophic).

WATERSHED: The total area draining into a lake, including the area of the lake itself. Also called drainage basin.

ZOOPLANKTON: Microscopic animal life that floats within or on top of a water body.

EXECUTIVE SUMMARY

1. Introduction

The Partridge Lake Diagnostic Study began in June of 2000, at the request of the Partridge Lake Association and was completed in May of 2001. The lake's watershed is located in the towns of Littleton and Lyman.

The goals of the diagnostic study were to identify and monitor the sources of water and nutrients (phosphorus) to Partridge Lake, to identify the degree of phosphorus loading, and make recommendations about lake and watershed management activities to improve lake water quality.

Prior to making recommendations for protective and restorative measures, a fuller understanding of such processes as lake flushing, watershed land use, and nutrient sources had to be achieved. To this end, biologists began an intensive study to document the physical, chemical and biological processes of Partridge Lake.

2. Hydrologic Budget

The hydrologic budget for the gauging period (June of 2000 to May of 2001) provided estimates of all significant sources of flow into Partridge Lake by gauging the inlets and outlet, estimating direct surface runoff, and measuring precipitation and evaporation. Direct runoff provided the greatest input to the lake (30 percent). Groundwater from nearshore seepage contributed the second largest source of water to Partridge Lake, yielding 29 percent of the water to the lake. Hydrologic inputs from tributaries were estimated to contribute 26 percent of the budget. Finally, precipitation contributed 15 percent of the total inputs. Overall, most of the water enters the lake from overland runoff (56 percent).

Outflow over the dam accounted for 46 percent of the water losses from the lake. Groundwater recharge represented an estimated 31 percent of the outflow budget for the sample year. Evaporation accounted for 11 percent of lake water losses, with change in lake storage accounting for the remaining 12 percent of the hydrologic budget.

3. Phosphorus Budget

Phosphorus loading, the primary factor limiting algae growth, was determined through water quality sampling and analysis of many of the sources quantified in the hydrologic budget. One of the most important goals of this study was to quantify phosphorus inputs to Partridge Lake.

Study year mean phosphorus concentrations for the inlets to Partridge Lake ranged from a low of 9 ug/L in tributary H, to a high of 16 ug/L in tributary G. The phosphorus concentration in tributary G is considered higher than desirable. The mean phosphorus concentration at the outlet stream was 15 ug/L.

Direct runoff was the greatest contributor of phosphorus to Partridge Lake, contributing 45 percent of phosphorus inputs. Inputs from groundwater seepage provided the next largest percentage of phosphorus to the lake (30%). Precipitation accounted for 17 percent of nutrient input to the lake. Year-round tributaries contributed 8 percent of the overall phosphorus loading from the watershed. Just over half of the budget (53%) can be influenced by land-based activities from the Partridge Lake watershed.

In-lake phosphorus concentrations at Partridge Lake ranged from an average of 12 ug/L in the upper layer (0.1-4 m) during the summer of 2000 to a mean of 293 ug/L in the lower layer (>10 m). The mean phosphorus concentration in the middle layer (4-10m) was 20 ug/L. Total phosphorus concentrations in the upper and middle layers fall within the "average" classification for New Hampshire lakes. Total phosphorus in the bottom layer, however, is considered "excessive." As watershed phosphorus inputs are not large enough to account for this high in-lake concentration, it is most likely caused by internal loading of phosphorus from bottom sediments.

Three different classification methods were utilized, and their results are compared for this study. One method classified the lake as mesotrophic, which is in the middle of the trophic spectrum; however the lake is very close to the eutrophic (most aged) end of the spectrum. The other two models classified Partridge Lake as eutrophic.

4. In-Lake and Tributary Data

Partridge Lake is a typical northeastern temperate lake exhibiting temperature-based stratification into three layers during the summer months. Partridge Lake shows declining oxygen concentrations below 5 meters, where late summer oxygen concentrations have reached nearly 0 mg/L. Fish species can become impacted when oxygen concentrations drop below 4 mg/L. This low oxygen forces fish out of the cooler deeper waters and into the warmer shallower waters during the summer months, potentially impacting the health of the fish. Over time, many lakes will experience anoxic waters deeper in the lake due to the accumulation and decomposition of organic matter in the lake bottom, but human activities in the lake's watershed such as tree clearing, fertilizing lawns, increasing impervious areas, and leaking septic systems can accelerate the accumulation.

Mean summer pH values for the lake ranged from a high of 7.33 units in the epilimnion to a low of 6.58 units in the metalimnion. The waters of Partridge Lake would fall within the "satisfactory" category, meaning the lake is near neutral. The acid neutralizing capacity (ANC) of the lake was high at 22.4 mg/L as $CaCO_3$, which places the lake in the "not sensitive" category for acid inputs, meaning that the lake is able to effectively buffer against acid additions from precipitation and runoff.

Mean summer conductivity values in Partridge Lake ranged from a low of 77.21 umhos/cm in the epilimnion, to a high of 95.51 umhos/cm in the hypolimnion. These are higher than the average conductivity value of 56.8 umhos/cm for New Hampshire water bodies, but they have not increased markedly since Partridge Lake joined the VLAP program.

Overall, turbidity values in the lake were low, with a summer mean of 0.44 NTU in the epilimnion and 2.55 NTU in the hypolimnion. Turbidity in the hypolimnion was higher than the NH VLAP mean of 1.0 NTU during summer 2000, however, the range of sample values varied considerably meaning that one or two higher readings may have skewed the average.

Algal populations during the summer months were comprised of a mix of golden brown algae and diatoms, dinoflagellate algae, and Cyanobacteria. A depth discriminate analysis of algal communities showed that Cyanobacteria appear to decline in abundance with depth. Cyanobacteria were the species of greatest interest because Cyanobacterial blooms have become a seasonal problem in Partridge Lake. The 2000 in-lake monthly mean summer chlorophyll-a concentration in Partridge Lake was 4.45 mg/m^3. This falls within the "good" range for algal abundance. Overall algal abundance has not increased markedly since regular sampling began in 1989 and has actually shown a more stable trend over time.

The mean monthly summer clarity was 5.3 meters. Partridge Lake clarity is higher than the mean clarity of most lakes and ponds in New Hampshire, and has remained stable since Partridge Lake joined VLAP.

Plant growth in Partridge Lake is common overall, consisting of lily communities, a few species of pondweed, and various rushes and sedges. Partridge Lake has currently not been impacted by exotic nuisance species such as milfoil or fanwort, but it is recommended that the Weed Watcher Program be continued, as nearby lakes and ponds do have milfoil.

Tributary Data

Mean summer pH values in the tributaries ranged from a low of 6.45 units in tributary L to a high of 7.43 in tributary H. These pH values are above the state mean and within the "satisfactory" range for New Hampshire surface waters.

Conductivity values varied between tributaries, with the highest mean value in tributary G (157.91 umhos/cm), which originates below a large field that is used for dairy cow grazing. Overall, tributary conductivity values are not within an alarming range.

Tributary turbidities were higher than those in the lake, as is to be expected. Tributary L had the highest mean turbidity during the study period. Overall, however, there does not appear to be an excessive amount of sediment entering the lake.

5. Lake and Watershed Recommendations

To create a more intensive and comprehensive protection and preservation strategy for water resources in Littleton and to help slow the aging process of Partridge Lake, the following watershed management strategies are recommended:

Stormwater Management and Erosion Control

Since overland runoff (channelized and overland) are the leading sources of both water and nutrients to Partridge Lake, the Partridge Lake Association and the Town of Littleton Public

Works should focus on stabilizing runoff ditches, culverts, and basins within the watershed. Specifically, Partridge Lake Road, South Shore Road, and Old Partridge Lake Road are all areas in which Best Management Practices should be developed and implemented to minimize erosion. Riprapping drainage ditches and vegetating settling basins along dirt roads would lessen sediment transport.

Septic System Management

All of the homes around Partridge Lake are on subsurface systems or holding tanks, and these systems can be phosphorus contributors to the lake. A survey of residents found that 36% of the systems around Partridge Lake have reached or exceeded their life span, and roughly 30% of the nutrient budget from the watershed sources is derived from groundwater seepage. It is recommended that these systems be replaced. A variety of alternative systems are also available, such as regional waste treatment, cluster systems, low water flush toilets and gray water flow reduction. It is recommended that *all* shorefront residents pump their systems every 1-3 years.

Shoreland Protection, Development, and Zoning

The protected shoreland is the area of land between the reference line (high water mark of the waterbody), to a point 250 feet upslope. To minimize erosion and the input of nutrients, a well-vegetated buffer should be established and maintained. There is a list of native plants, shrubs, and trees available for vegetating the shorefront. A well-distributed stand of trees, shrubs, and groundcover can help maintain a healthy shoreline. Setbacks under the Shoreland Protection Act for buildings and other such structures should be strictly adhered to.

The Partridge Lake Association and the town of Littleton should work toward enacting zoning ordinances and an environmental or watershed overlay district that is consistent with the Shoreland Protection Act. This would not change the zoning for the whole town, but simply for the delineated watershed area of Partridge Lake. The Comprehensive Shoreland Protection Act is a good starting point to use as a model in developing guidelines for the overlay. NHDES recommends that representatives from the Partridge Lake Association and the town of Littleton form a subcommittee to investigate options for developing zoning ordinances and protective overlays for areas near the lake, as well implementing Low Impact Development strategies in the watershed.

Beach Erosion

To prevent runoff and subsequent erosion from beaches, all sandy areas should be stabilized by 'perching' beaches with a low natural rock wall at the toe of the slope, and installing a drainage ditch along the upper margin of the beach to divert runoff around the sand, rather than across the sand. These activities, and any shoreline activities, require a permit from the NHDES Wetland Bureau.

In-Lake Management – Phosphorus Inactivation

Phosphorus precipitation and sediment inactivation through aluminum salts injection are lake restoration techniques that can reduce internal phosphorus loading and thereby limit the growth of algae in the lake. This method of in-lake phosphorus reduction was successful in Kezar Lake in North Sutton, New Hampshire. It is important to note that all watershed sources of phosphorus must be eliminated or reduced prior to the use of this technique or they would counteract the goal of the treatment.

Aquatic Plant Management

With increasing numbers of exotic plant infestations throughout New Hampshire, it is important that lake association members continue to monitor Partridge Lake for new growths of exotic plant infestations as part of the NHDES Weed Watcher program. The lake association should encourage more residents to become volunteer Weed Watchers.

Education

The Partridge Lake Association should continue its activities to educate lake residents and transient recreationists about shoreland protection and broaden its efforts to encompass residents within the entire watershed. The Association should also establish a shoreland vegetation program and encourage the use of new technology efficient marine engines. Elementary and secondary schools in the town of Littleton can participate in the NHDES

Interactive Lake Ecology Program. Public education within the watershed is particularly important as more lake residents begin to convert seasonal homes to year-round residences.

Future Monitoring

The Partridge Lake Association should continue to participate in the Volunteer Lake Assessment Program, monitoring once a month in the summer.

Lake and Watershed Restoration Projects

Alternative funding sources may be required to implement some of the recommendations of this report. One possible funding source is the NHDES Nonpoint Source (NPS) Local Initiative Grant Program. In order to apply for the grant program, you must submit a proposal the meets the requirements of the annual Request for Proposal, usually issued in early September. Please contact the NPS Program Coordinator if you are interested in pursuing water quality improvement funds through this grant program.

1.0 INTRODUCTION AND WATERSHED CHARACTERISTICS

1.1 Purpose of Study

The Partridge Lake Diagnostic Study began on June 1, 2000 and was completed on May 31, 2001. The study was funded by a Local Lake and Watershed Non-Point Source grant through NHDES. The Partridge Lake Association provided volunteer monitors throughout the course of the study. The project was undertaken to provide both limnologists and lake residents the opportunity to learn more information about the watershed and the lake, as well as to determine nonpoint sources of pollution to the lake (particularly phosphorus loading).

Partridge Lake is used mostly by lake residents and transient boaters and fishermen. The Partridge Lake Association has been actively monitoring water quality for over 13 years through the Volunteer Lake Assessment Program (VLAP). Recently, lake monitors and DES biologists have noted cyanobacteria blooms, decreased Secchi depth readings, increased chlorophyll-a concentrations, and decreases in hypolimnetic oxygen concentrations.

The goal of this study was to determine the watershed sources of phosphorus to the lake and to make recommendations for the overall enhancement and protection of Partridge Lake through watershed management and/or in-lake restoration. To achieve this, a hydrologic budget was constructed by measuring water inputs from tributaries, wetfall, direct runoff and groundwater seepage while outputs were measured at the outlet, through evaporation and groundwater discharge. A phosphorus budget was then constructed by measuring concentration of each input and output of the lake to derive a mass balance of phosphorus load (Kg) to the lake. A series of trophic models were run to aid biologists in trophic lake classification and possible phosphorus reduction scenarios to improve lake quality. This report summarizes the results of the study and makes recommendations to improve the quality of Partridge Lake through watershed management and possible in-lake restorative techniques.

1.2 Lake and Watershed History

Partridge Lake was named after Nathaniel Partridge, an old time resident that once owned a large amount of the land surrounding the lake.

A few small family businesses were established in the Partridge Lake area beginning around the 1700s. John Fuller ran a boarding house near Partridge Lake and rented boats and fed horses for lake visitors. The Chaffees were farmers in the Partridge Lake area for five generations, beginning in the late 1700s.

Until the early 1900s, when it became a resort area with private cottages, the lake was known as Partridge Pond. Partridge Lake has always been filled naturally with trout, and in 1820 John White, hired by Nathaniel Partridge, stocked it with pickerel. The road to Partridge Lake began across from the Pattenville Schoolhouse, although the start of the road is now underwater. The remaining part is known as Old Partridge Lake Road.

In 1953, construction of the Moore Dam required 3,500 acres to be flooded with water from the Connecticut River. The flooding ran almost to Partridge Lake and flooded mostly agricultural lands.

1.3 Lake Characteristics

Partridge Lake is a naturally occurring lake in northwestern New Hampshire, located in the town of Littleton. The lake is impounded by a small dam at the southwestern end. Table 1-1 summarizes the characteristics of the lake. A bathymetric (depth) map is shown in Figure 1-1. A map delineating the watershed boundary can be found in Figure 1-2.

1.4 Climate

The climate of the region is characterized by moderately warm summers, cold, snowy winters, and ample rainfall. Precipitation in this region is typically acidic. Generally, snow is present from mid-December until the end of March or early April. Ice-out for the lake is usually mid-April.

1.5 Watershed Characteristics

The Partridge Lake watershed encompasses an area of approximately 344 hectares (1.33 square miles). This watershed contains the major lake and several wetland areas. The lake covers 42.05 hectares (103.9 acres), and wetlands comprise approximately 21.8 acres. In addition, there are four year-round streams, several seasonal streams and several areas of overland seasonal runoff entering Partridge Lake (see Figures 1-1 and 1-2).

Seasonal runoff, direct runoff, tributary flow, and groundwater seepage contribute to the hydrologic inputs of Partridge Lake. The inlets and the outlet are shown in Figure 1-1. The outlet stream flows in a southwesterly direction from the lake where it eventually enters Dodge Pond to the south.

Table 1-1
Morphometric Data

Parameter	**Lake Information/ Morphometric Data**
Lake Name	Partridge Lake
Town	Littleton
County	Grafton
River Basin	Connecticut
Latitude	44°18'28"N
Longitude	71°53'16"W
Elevation (ft)	846
Shoreline Length (meters)	4,500
Watershed Area (ha)	344
Lake Area (ha)	42.05
Maximum Depth (m)	15.2
Mean Depth (m)	5.8
Volume (m^3)	2,434,000
Areal Water Load (m/yr)	3.65
Flushing Rate (yr^{-1})	0.6
Phosphorus Retention Coefficient	0.71
Lake Type	Natural with dam

Figure 1-1
Partridge Lake Bathymetric Map

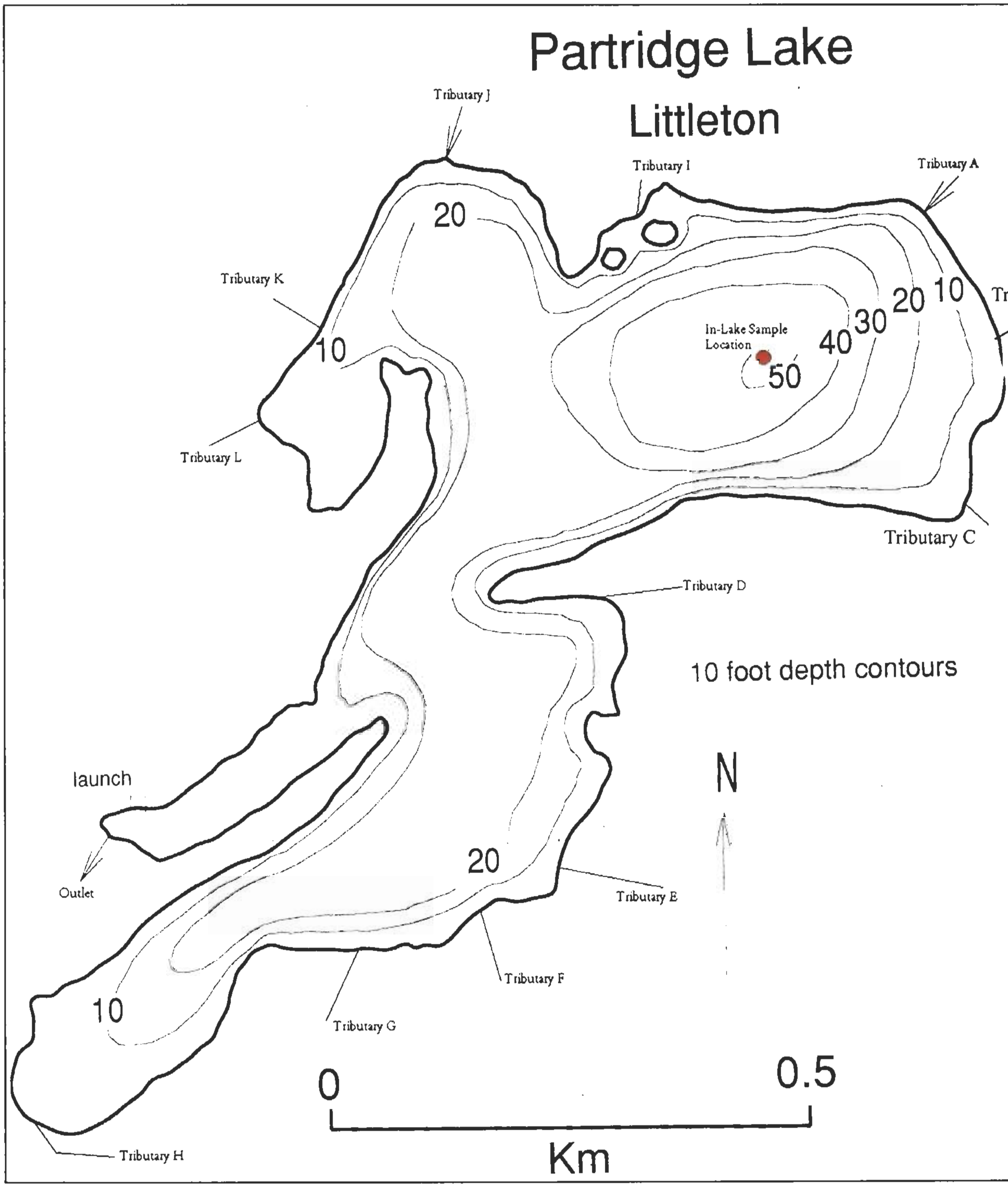
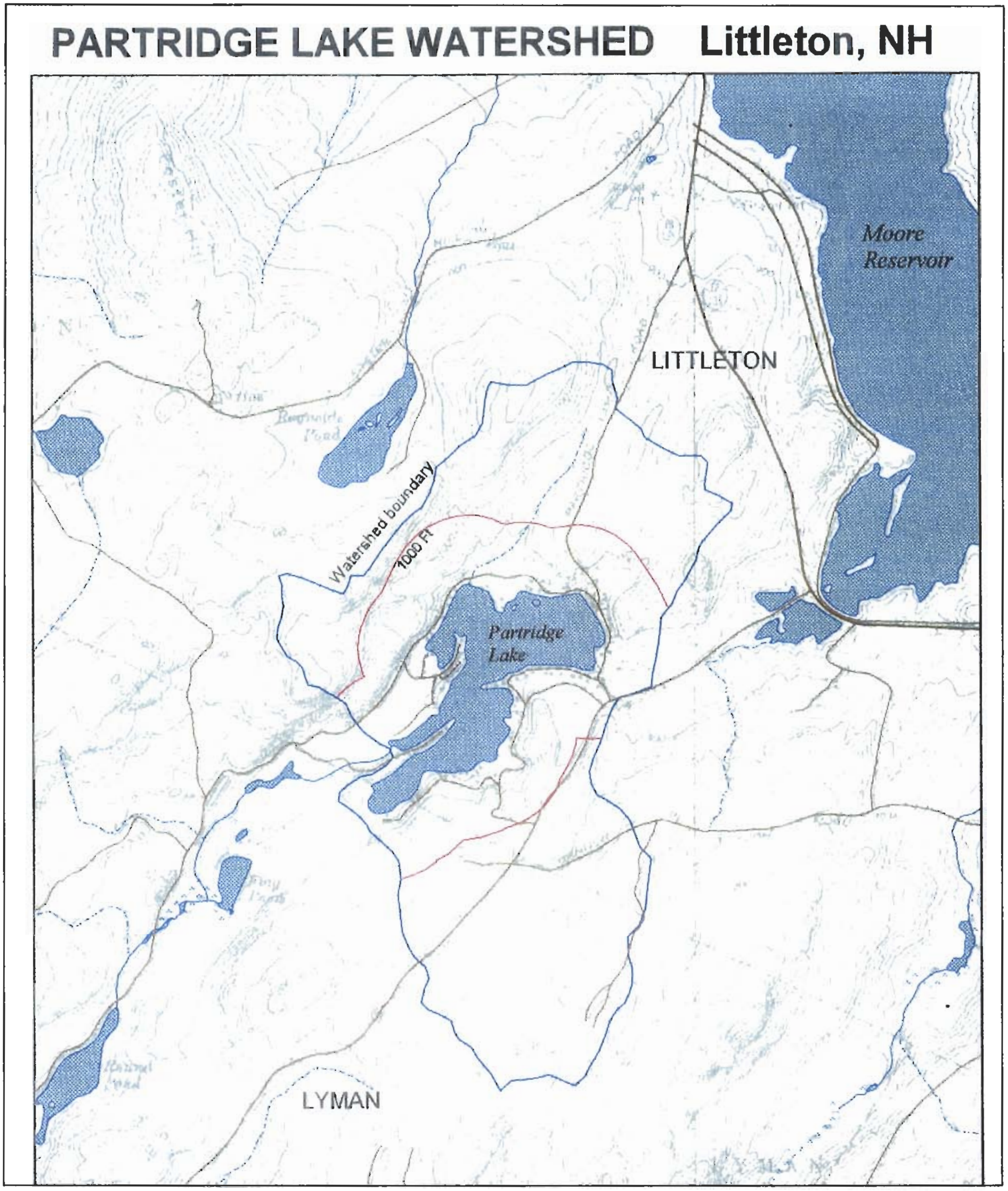


Figure 1-2
Partridge Lake Base Map



1.6 Soils, Land Cover, and Land Use Patterns

There are three types of rock found in the Littleton area: granite, metamorphic rock (which often contain minerals such as feldspars, quartz, garnets, and graphite), and slate and sandstone. Silurian fossils were discovered on September 28, 1870 in the town of Littleton.

Partridge Lake watershed soils are comprised of a mix of Berkshire loams, Marlow and Peru fine sandy loams, and Tunbridge-Lyman rock outcrops. Loamy sand of the Colton, Adams, and Waumbek families, and Monadnock and Hermon soils are also found in the watershed. In general, permeability is rapid throughout the watershed.

The quality of a lake is influenced, in part, by the type of human and natural activities that occur within the confines of its watershed. Much of the rainwater, snow melt-water and groundwater found within the watershed will eventually end up in the lake. The downward migration of the surface and groundwater carries pollutants found in the watershed, including nutrients such as phosphorus and nitrogen. Inputs of phosphorus to the lake may increase algal and cyanobacteria growth and accelerate eutrophication.

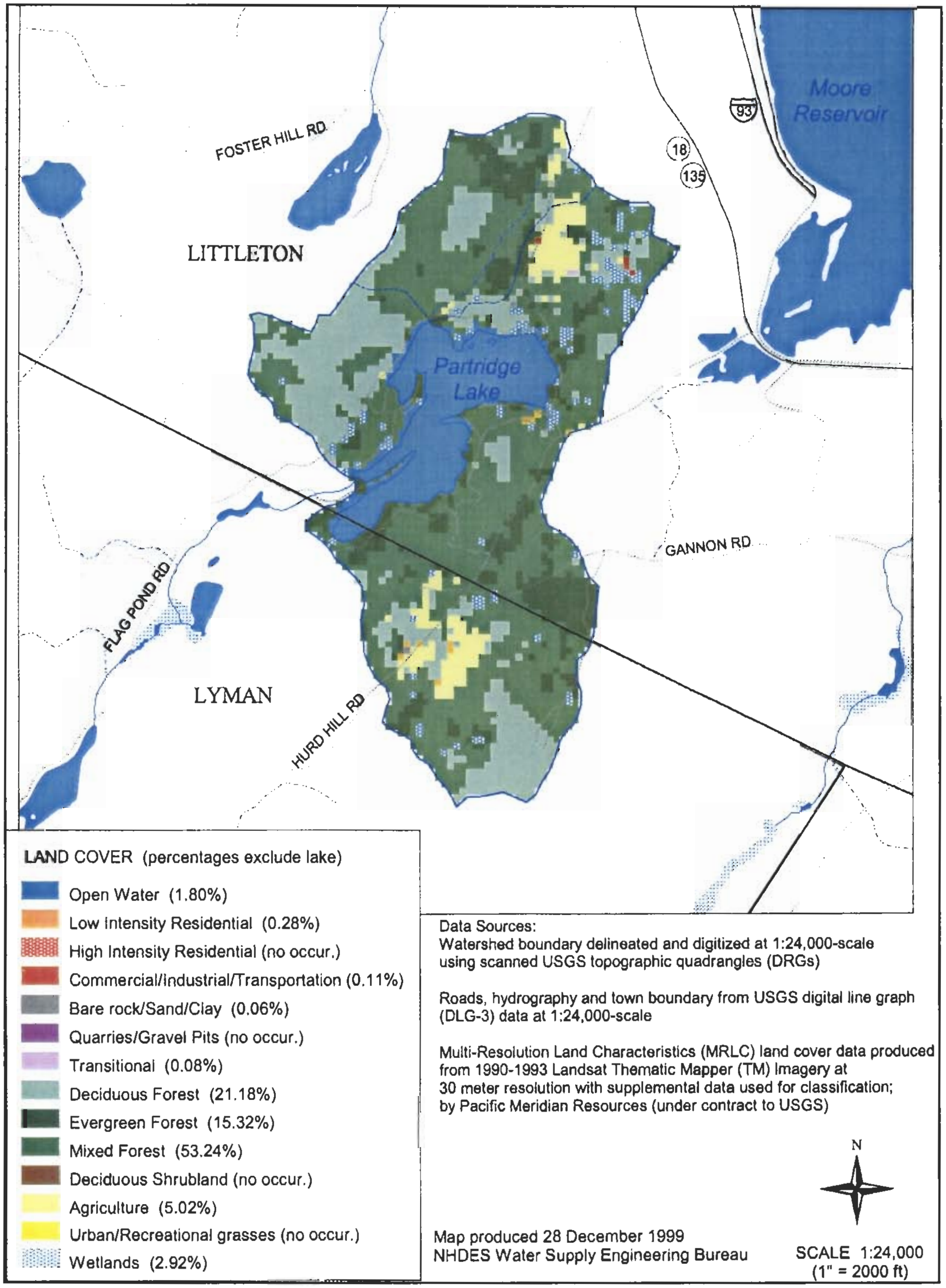
Increases in developed areas, failed septic systems, the removal of native vegetation during construction, and increases in impervious surfaces are the most common human activities that impair lake quality and accelerate cultural eutrophication. Human disruptions of a watershed will accelerate the degradation of water quality much faster than natural processes.

1.6.1 Partridge Lake Land Use

Data pertaining to existing land use in the Partridge Lake watershed were obtained from a land use map prepared by the Informational Resources Management Unit at NHDES. The map was derived from a 1990-1993 Landsat TM image and supplemental data sources. Figure 1-3 illustrates the land use cover in the Partridge Lake watershed. Table 1-2 shows an estimated breakdown (in acres) of the current land use in the Partridge Lake watershed.

As the figure and table indicate, the predominant land cover type within the Partridge Lake watershed is forested. The forested portion of the watershed can be characterized as a

Figure 1-3
Partridge Lake Watershed Land Use Map



mixed forest, with white pine and eastern hemlock comprising the evergreen component, and beeches, maples, and oaks comprising the majority of the deciduous trees.

Table 1-2
Partridge Lake Watershed Land Cover (Acres)

Land Use	Acreage
Forested	711.42
Lake	103.9
Residential/Commercial	71.8
Wetland	21.8
Active Agriculture	39.81
Cleared/Other	1.11

Forested lands are beneficial in that the rooting systems of the plants and trees take in excess nutrients from the soil, thereby preventing the likelihood of these nutrients entering the lake. These rooting systems also provide the added benefit of soil stabilization. The root masses from the trees and shrubs form a support network, holding soil particles together, thereby preventing erosion. In addition, forests provide a shading effect around the edge of the lake, preventing excessive heating of the lake water.

Surface water is the next largest land coverage in the watershed. This category includes Partridge Lake and the open water or ponded areas of wetland habitats. For the most part, wetlands in the watershed do not have large areas of open water. Most of the wetlands are forested or emergent marshes.

Residential development covers a total 71.8 acres of the watershed. Areas of low intensity residential development occur along nearly the entire shoreline of Partridge Lake. Development in the Partridge Lake watershed is characterized by seasonal cottages along the shoreline, with larger year round homes farther back from the lake edge. Recent trends toward conversion of these seasonal homes to large permanent homes with all modern facilities (i.e. washing machines, garbage disposals, dishwashers, showers) all lead to an increased load to septic systems and an increased phosphorus load to the groundwater.

2.0 WATER BUDGET

2.1 Introduction

The purpose of a water budget is to measure the volume of all water entering and leaving a lake. Inflows such as tributary flow, overland flow, direct precipitation, and groundwater input all contribute to the water budget of the lake. The outflow of the lake, evaporation, and areas of groundwater recharge from the lakebed are all sources of outflow.

Chapters 2 through 4 contain technical scientific methodologies that may require further reference reading. Please reference the Standard Operating Procedures of the NHDES Limnology Center and the NHDES Laboratory Services for protocols and methods used for sampling and analysis.

2.2 Budget Components

2.2.1. Precipitation/Evaporation

The data for the precipitation and evaporation calculations were obtained from the NOAA weather station in Bethlehem, NH (for precipitation data only) and the NOAA weather station in Rangely, Maine (for evaporation only) where daily weather trends are recorded. These are the nearest reliable weather stations to the Partridge Lake area. Tables 2-1 and 2-2 summarize the precipitation and evaporation trends (respectively) during the study year.

The total amount of annual precipitation and evaporation are multiplied by the surface area of the lake to determine the volume of water that fell directly on the lake, and that evaporated directly from the lake surface area using the Pan Coefficient for standardization.

2.2.2. Tributary Inputs and Outflow

Tributary inputs, as well as the outlet outflow, are calculated using regression analyses based on the monthly stream flow readings conducted by NHDES, and on the bi-weekly staff gauge readings by the Partridge Lake volunteers. Raw data and statistical summaries for the hydrologic budget can be found in Appendix 1.

Table 2-1
Partridge Lake Monthly Precipitation (June 2000-May 2001)

Month	Precip (in)	Precip (m)	Precip (m3)	Precip (103m3)	Percent
Jun-00	2.43	0.06	25954.10	25.95	8.99
Jul-00	3.58	0.09	38236.91	38.24	13.24
Aug-00	3.29	0.08	35139.50	35.14	12.17
Sep-00	2.37	0.06	25313.26	25.31	8.77
Oct-00	2.28	0.06	24352.00	24.35	8.44
Nov-00	3.41	0.09	36421.19	36.42	12.62
Dec-00	2.35	0.06	25099.65	25.10	8.69
Jan-01	0.09	0.00	961.26	0.96	0.33
Feb-01	2.16	0.05	23070.31	23.07	7.99
Mar-01	2.11	0.05	22536.28	22.54	7.81
Apr-01	1.05	0.03	11214.74	11.21	3.88
May-01	1.91	0.05	20400.14	20.40	7.07
Total	**27.03**	**0.69**	**288699.32**	**288.70**	**100.00**

Surface Area= 420,500 m^2 Precip (m^3)=Monthly (m) X Surface area

Table 2-2
Partridge Lake Monthly Evaporation Rates (June-September 2000 & May 2001)
(Pan Coef.)(Lake Surface Area)(Monthly Evap.)

Month	Total Evap (in)	Total Evap (m)	Evaporation (m3)	Evaporation ($10^3 m^3$)	Evap (Pan Coef.)
Jun-00	5.12	0.13	54685.18	54.69	42.11
Jul-00	5.25	0.13	56073.68	56.07	43.18
Aug-00	4.11	0.10	43897.68	43.90	33.80
Sep-00	3.25	0.08	34712.28	34.71	26.73
May-01	5.88	0.15	62802.52	62.80	48.36
Total	**23.61**	**0.60**	**252171.33**	**252.17**	**194.17**

Surface area = 420,500 m^2 Pan Coef = EV($10^3 m^3$) X .77

2.2.3. Direct Runoff

Water that enters the lake from nearshore zones, and that does not enter a tributary, is referred to as direct runoff. This is estimated by examining the shoreline configuration and determining the zone where direct runoff may occur. A map is consulted, and a line is drawn around the shoreline to indicate the zone. Land area is then estimated for that zone. Next, runoff estimates (in inches) are determined from the examination of the Knox and Nordensen Atlas

(Knox and Nordensen, 1955). Runoff depth is then multiplied by the area that drains directly to the lake. Monthly inputs are determined by multiplying this total value by the percent of annual rainfall for each month.

2.2.4 Groundwater Inputs and Recharge

Groundwater recharge was estimated from nearshore littoral zone seepage which was measured through seepage meters installed in the lake bed. Six sites were established in the lake in varying sediment types and shoreline population densities. Seepage contributions were calculated by multiplying lake bottom area (area of lake bed from a depth of 10 ft shoreward) by the seepage rate of the nearest barrel. Seepage discharge was weighted by shoreline development density and shoreline substrate type.

2.3 Water Budget

Each of the previously detailed components is combined to form a comprehensive water budget based on the following equation:

Tributary Inputs + Direct Runoff + Groundwater inputs (seepage) + Direct precipitation – Evaporation – Outflow – Groundwater Recharge = Change in Storage

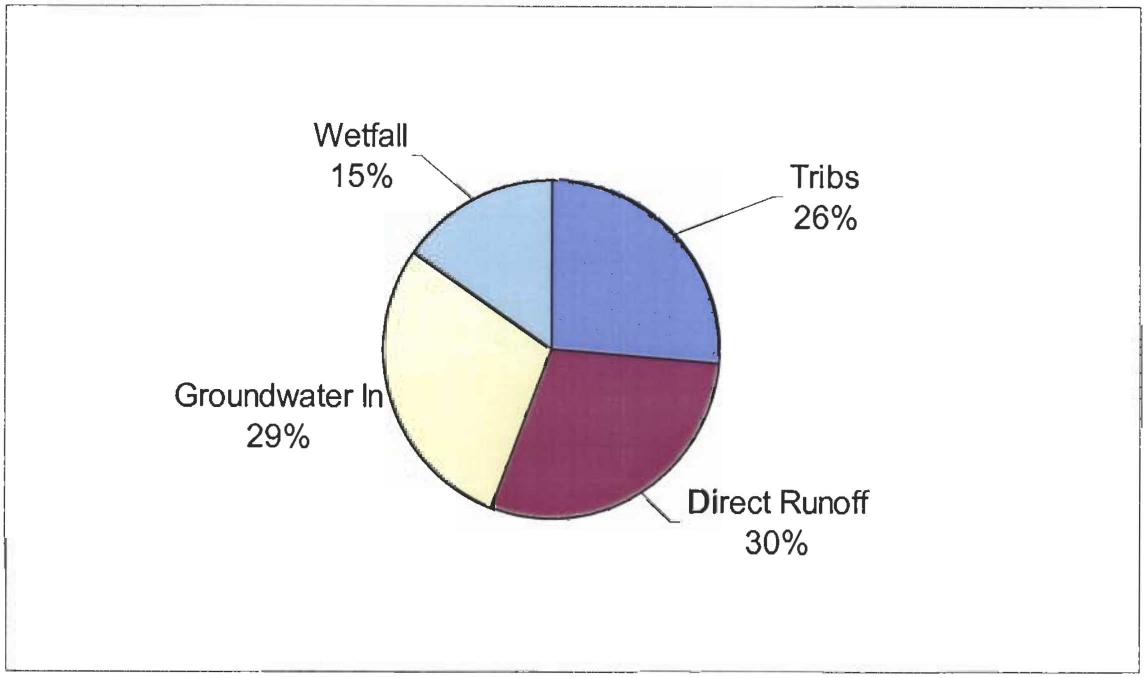
According to the completed water budget (Figure 2-1 and Table 2-3), inputs from overland runoff contribute the greatest volume of water to Partridge Lake (30%). This means that most of the water that enters Partridge Lake has run over the watershed before discharging to the lake, allowing it to pick up both natural and human introduced contaminants along the way.

Groundwater inputs from nearshore seepage contribute the next largest source of water to the lake (29%). According to the Soil Conservation Service data, soils are sandy and depth to bedrock is shallow around most of the watershed, allowing water that infiltrates into the soil to travel rapidly downgradient to the lake. Additionally, several springs are observed around the lake edge, disappearing below ground intersecting bedrock and discharging to the lake littoral zone.

Year-round tributaries contribute the third largest source of water to Partridge Lake (26%). There are only four tributaries that can be considered year-round in the Partridge Lake watershed. For the most part, these streams are distributed at fairly equal distances from one another around the lake edge, with smaller seasonal streams scattered between each year-round inlet.

Hydrologic inputs from precipitation that fell directly on the lake surface comprise the last 15% of the water budget for Partridge Lake. This fraction enters from the atmosphere, bringing with it particulates and other matter that mix with rainwater and snow.

Figure 2-1
Partridge Lake Hydrologic Inputs



Precipitation contributions for December through February are added to the March value. It is assumed that precipitation falling in these months is in the frozen form, and that it is not mobile until the spring melt.

As for tributary inputs, Tributary J contributed the largest volume of water to Partridge Lake (32%) over the course of the study year. Tributary A was the next largest contributor (30%), followed by Tributary G (26%) and Tributary H (12%). Tributary A was the most consistently flowing stream in the watershed, but it has a narrow, shallow channel and small subwatershed area that makes this tributary the second largest contributor. All other tributaries monitored had short periods of no flow during the study, particularly during the summer and fall period. Figure 2-2 shows the tributary inputs to Partridge Lake.

Table 2-3
Partridge Lake Hydrologic Budget ($10^3 m^3$)

Partridge Lake Hydrologic Budget Table- Monthly (Volume reported as $10^3 m^3$)

Hydrologic Component	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	*Annual Total*	*Monthly Average*
A	10.08	2.60	7.96	10.63	19.96	19.20	11.40	11.40	10.93	8.25	33.23	5.42	*151.05*	*12.59*
G	12.75	9.43	1.50	1.89	3.13	2.08	6.53	7.65	5.58	8.72	43.45	24.22	*126.94*	*10.58*
H	5.64	5.64	1.57	1.93	6.00	4.53	0.00	14.03	0.00	0.00	21.47	0.45	*61.29*	*5.11*
J	8.83	5.96	3.80	0.00	8.03	11.75	15.42	9.00	7.33	13.81	68.43	6.03	*158.40*	*13.20*
Direct Runoff	49.30	73.95	65.73	49.30	49.30	73.95	49.30	ice/snow	ice/snow	ice/snow	106.81	41.08	*558.70*	*62.08*
Gwi****	36.41	33.36	28.45	37.71	33.00	33.00	33.00	40.29	59.00	62.31	33.00	56.32	*485.84*	*40.49*
Direct Wetfall	25.95	38.24	35.14	25.31	24.35	36.42	25.10	ice/snow	ice/snow	ice/snow	57.78	20.40	*288.70*	*32.08*
Total Inflow	**148.97**	**169.18**	**144.15**	**126.76**	**143.77**	**180.94**	**140.75**	**82.38**	**82.84**	**93.08**	**364.17**	**153.93**	***1830.92***	***152.58***
Outlet/Dam	33.73	14.94	37.43	11.81	48.06	65.51	78.03	82.38	82.84	93.08	228.29	72.71	*848.81*	*70.73*
Evaporation	42.11	43.18	33.80	26.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.36	*194.18*	*16.18*
Estimated Gwo	41.72	100.73	54.47	82.10	73.21	88.72	36.87	0.00	0.00	0.00	93.52	0.00	*571.35*	*47.61*
Change in Lake Basin Storage**	31.41	10.34	18.45	6.12	22.50	26.70	25.85	0.00	0.00	0.00	42.36	32.85	*216.58*	*18.05*
Total Outflow*	***117.56***	***158.84***	***125.70***	***120.64***	***121.27***	***154.24***	***114.90***	***82.38***	***82.84***	***93.08***	***321.81***	***121.08***	***1614.34***	***135.75***

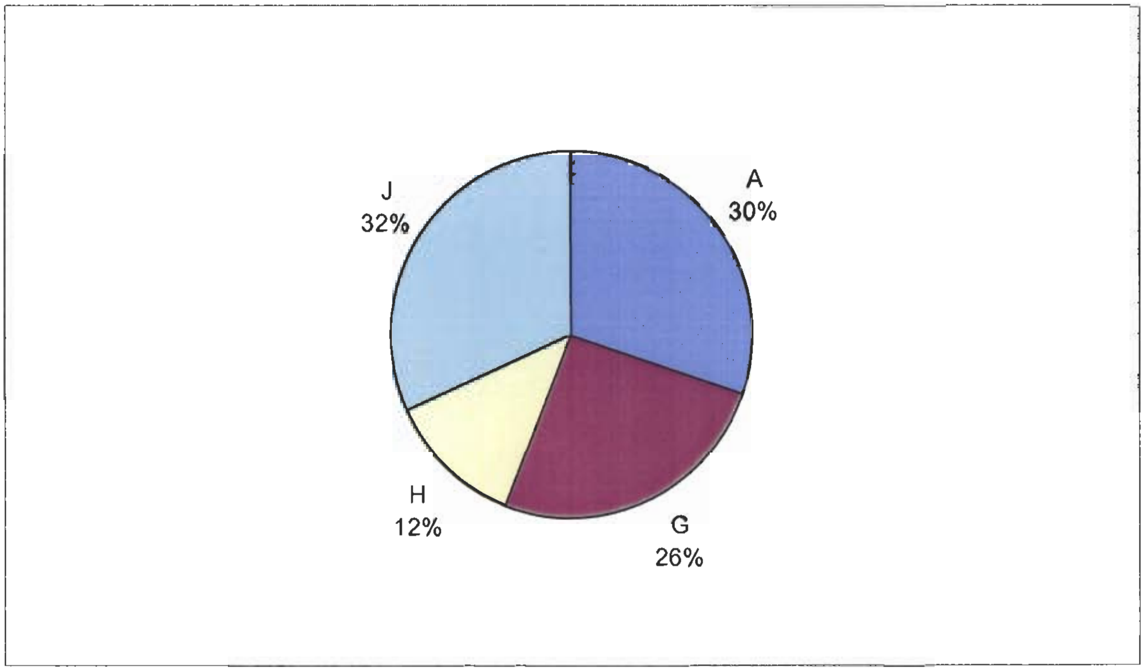
*GW0= Total inflow-dam outflow-evaporation-lake storage

**aka water retention. Based on lake level fluctuations from full lake (lake level was slightly elevated throughout study year).

***Total outflow=dam outflow+evaporation+GWo

****Gwi was not monitored from Oct 00-May 01, therefore the mean Gwi for the measured period was applied to these months to account for Gwi contributions during the ungaged portion of the study)

Figure 2-2
Partridge Lake Tributary Inputs



The largest outflow of water was from the outlet structure (46%). Groundwater recharge (estimated by difference) accounted for the second greatest loss of water from the lake (31%). Evaporation from the lake surface accounted for 11% of the water losses. The change in lake storage accounted for 12% of the lake volume during the study year (calculated by multiplying lake level fluctuations by lake surface area at full lake). Figure 2-3 shows the percentages of outflow from Partridge Lake.

Figure 2-4 illustrates the trends in total inflow versus total outflow for Partridge Lake. In general, both inputs and outputs follow the same general pattern, and the space between the two lines is the estimated amount of water held as storage in the lake at a given time during the study period. Over the course of the study year the lake retained approximately 12% of the overall volume entering the basin as storage.

Figure 2-3
Partridge Lake Hydrologic Outputs

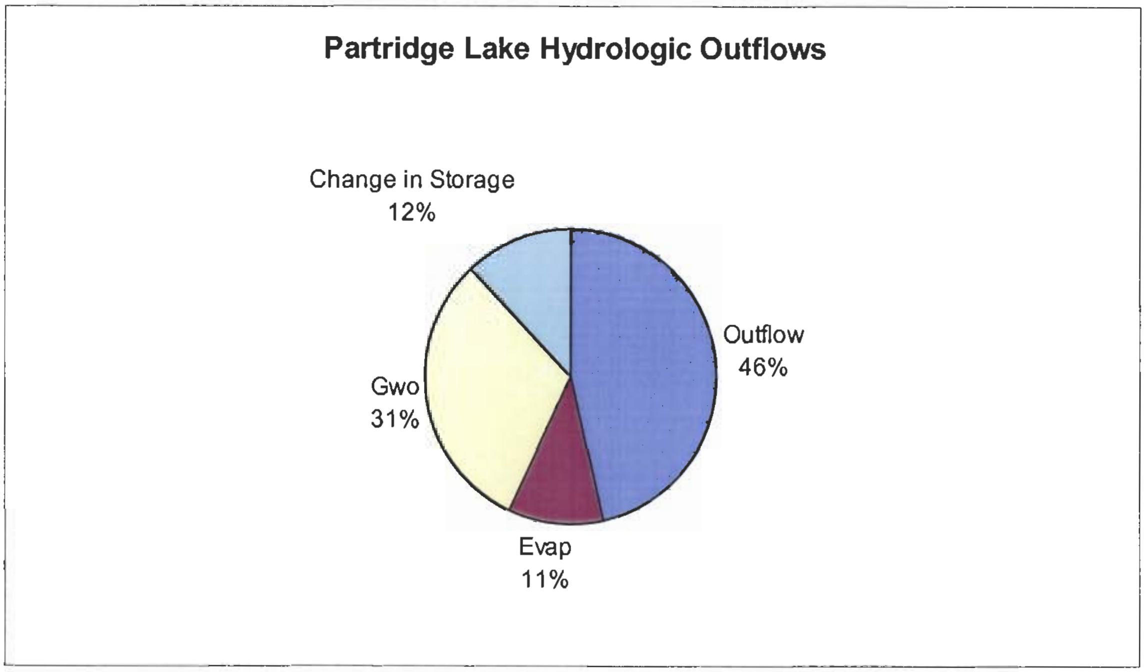
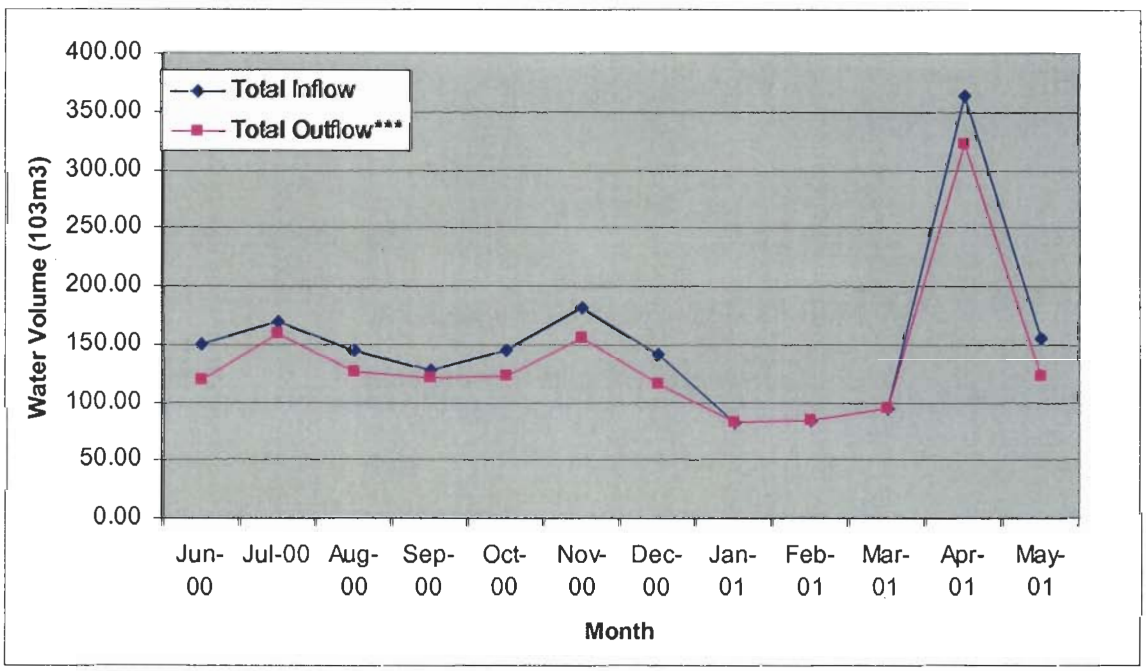


Figure 2-4
Partridge Lake Hydrologic Balance



3.0 TOTAL PHOSPHORUS BUDGET

3.1 Introduction

This chapter analyzes the inputs of phosphorus to Partridge Lake. The previous chapter detailed the components of the lake hydrologic budget. Each component of the hydrologic budget was multiplied by the phosphorus concentration in the water to calculate the total mass of phosphorus (Kg) entering and leaving the lake (total phosphorus concentrations exiting the lake through groundwater recharge and evaporation were not measured).

Only a small amount of phosphorus loading to a lake is needed to aid in plant cell production. Plants and algae require this nutrient in the photosynthesis process to produce their food. It only takes a small amount of phosphorus in relationship to other nutrients to produce excess plant and algae growth and is why phosphorus is referred to as the 'limiting nutrient'.

Phosphorus can be derived from natural or anthropogenic sources in a watershed. Phosphorus is a naturally occurring nutrient in our environment. Chemical reactions during weathering processes result in a release of phosphorus into the soil. Once the chemical bond is broken, phosphorus can attach to fine particulates and make their way into the atmosphere from wind currents. Atmospheric phosphorus reach our lakes as dry or wet deposition. Phosphorus is also tied up in organic matter (living things) such as animals, plants, insects, and humans.

In addition to natural sources of phosphorus, there are many other human induced contributions of phosphorus to a lake or pond. Human waste products, dishwashing detergents, gasoline and fertilizers all contribute varying amounts of phosphorus to our environment.

The nutrient budget is essential in quantifying the sources of phosphorus from the watershed, the lake and atmosphere. Once the phosphorus load to the lake is quantified, watershed management projects can be constructed to reduce or eliminate the sources to the lake.

3.2 Nutrient Budget Components

The nutrient budget is based on the same components that were used to develop the water budget, with the added parameters from wildlife inputs and internal loading inputs, as applicable:

Tributary Inputs + Groundwater inputs + Direct bulk precipitation + Wildlife contributions (where appropriate) + Internal Loading from sediments (where appropriate) – Outflow – Transfer to sediments (where appropriate) = Change in Storage

Using the volumes from the hydrologic budget, many of the calculations in this chapter were derived by multiplying the average phosphorus concentrations for each input by the volume of water from each input to yield total phosphorus loading. Calculations and raw data for the nutrient budget calculations can be found in Appendix 2. Figure 3-1 graphically depicts the loading of phosphorus to Partridge Lake. Table 3-1 details the total phosphorus inputs to Partridge Lake.

3.3 Total Phosphorus Inputs

Figure 3-1 depicts the external sources of phosphorus to Partridge Lake from its watershed. It is important to distinguish between phosphorus sources entering the lake from the watershed, versus those entering the lake from internal recycling or internal loading. Once all watershed sources of phosphorus are addressed, attention can be focused on in-lake remediation. The following discussion focuses on phosphorus sources from the watershed to Partridge Lake.

Figure 3-1
Partridge Lake Total Phosphorus Inputs (Kg/yr)

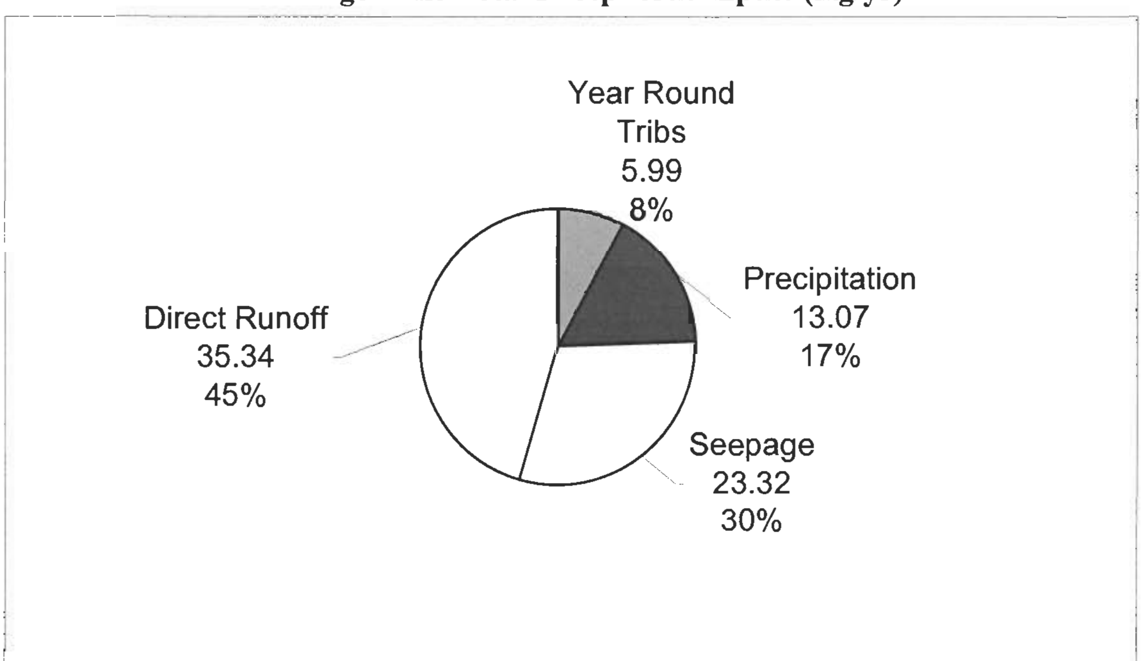


Table 3-1
Partridge Lake Total Phosphorus Budget (Kg TP)

Budget Component	*Jun-00*	*Jul-00*	*Aug-00*	*Sep-00*	*Oct-00*	*Nov-00*	*Dec-00*	*Jan-01*	*Feb-01*	*Mar-01*	*Apr-01*	*May-01*	***Annual Total***	***Annual Mean***
A	0.09	0.03	0.06	0.06	0.14	0.12	0.09	0.10	0.11	0.09	0.56	0.03	***1.48***	***0.12***
G	0.23	0.18	0.03	0.03	0.04	0.01	0.06	0.08	0.05	0.11	1.14	0.40	***2.36***	***0.20***
H	0.08	0.07	0.02	0.01	0.06	0.02	0.00	0.10	0.00	0.00	0.23	0.00	***0.59***	***0.05***
J	0.07	0.03	0.05	0.00	0.06	0.06	0.00	0.24	0.04	0.12	0.86	0.03	***1.56***	***0.13***
Direct Runoff	3.18	4.68	4.30	3.10	2.98	4.46	3.07	snow/ice	snow/ice	snow/ice	7.07	2.50	***35.34***	***3.93***
Direct Wetfall	2.98	4.40	1.65	1.87	0.66	0.22	0.28	snow/ice	snow/ice	snow/ice	0.71	0.31	***13.07***	***1.45***
Nearshore Seepage	1.75	1.60	1.37	1.81	1.58	1.58	1.58	1.93	2.83	2.99	1.58	2.70	***23.32***	***1.94***
Hypolimnetic Loadin	81.67	20.76	0.00	0.00	0.00	15.70	0.00	0.00	0.00	0.00	0.00	0.00	***118.13***	***9.84***
Total Inflow	**90.05**	**31.75**	**7.46**	**6.89**	**5.52**	**22.17**	**5.08**	**2.46**	**3.03**	**3.31**	**12.15**	**5.97**	***195.85***	***16.32***
Outlet/Dam	0.34	0.14	0.46	0.14	0.40	0.92	1.69	3.06	1.31	1.64	2.51	0.75	***13.37***	***1.11***
Retention in Lake	***89.72***	***31.61***	***7.00***	***6.74***	***5.12***	***21.25***	***3.39***	***-0.61***	***1.72***	***1.67***	***9.64***	***5.22***	***182.48***	***15.21***

3.3.1 Runoff from Ungauged and Gauged Watersheds

The largest contributor of phosphorus to Partridge Lake is direct runoff from the nearshore watershed. These inputs accounted for 43% (35.34 Kg TP) of the phosphorus load. A phosphorus coefficient for each land use was estimated by matching similar land uses at Partridge Lake to those with a known phosphorus export coefficient in the northeast region. These land use types and their associated phosphorus export coefficients are shown in Table 3-2. The direct phosphorus runoff was calculated by multiplying the summed land use area of ungaged watersheds by the phosphorus coefficient. To determine monthly inputs, this loading was multiplied by the percent of annual precipitation that fell during that month that would ultimately mobilize phosphorus movement to the lake.

Table 3-2
Partridge Lake Watershed Phosphorus Export

Land Use	Acres	Hectares	Coefficient	Kg/ha/yr TP Load
Beech/Oak	22.29	9.02	0.20	1.80
Cleared/Other	9.07	3.67	0.50	1.84
Hay/Rotation/Pasture	2.69	1.09	0.60	0.65
Hemlock	48.93	19.80	0.20	3.96
Mixed Forest	70.79	28.65	0.20	5.73
Open Water	20.33	8.23	0.00	0.00
Other Hardwoods	53.39	21.61	0.20	4.32
Paper Birch/Aspen	105.03	42.51	0.20	8.50
Spruce/Fir	0.77	0.31	0.20	0.06
Transportation	13.53	5.48	0.50	2.74
White/Red Pine	70.03	28.34	0.20	5.67
Wetland	3.33	1.35	0.05	0.07
Total				**35.34**

3.3.2 Nearshore Groundwater

Nearshore, or littoral zone groundwater inputs were the second largest contributor of phosphorus to Partridge Lake (30% or 23.32 Kg TP). It is important to note that roughly 36% of the septic systems near the lake edge are greater than 20 years old (DES data), and could be contributing phosphorus to the lake. Septic system contributions may also be compounded by the nature of the area (shallow depth to bedrock and sandy soils). Phosphorus loading from septic system leachate, coupled with phosphorus release from decaying organic matter, are rapidly picked up in shallow groundwater moving towards the lake, and are deposited nearshore in groundwater seepage to the lake.

3.3.3 Precipitation

Total Phosphorus inputs from wetfall and dryfall precipitation accounted for the third largest input of phosphorus (18% or 13.1 Kg.) to Partridge Lake Total phosphorus concentrations in precipitation ranged from 9 ug/L to 115 ug/L, with a mean annual concentration of 40 ug/L.

3.3.4 Year-Round Tributaries

Table 3-3 summarizes the average phosphorus concentrations in the tributaries to Partridge Lake, as well as the total annual phosphorus load and percent loading.

Year-round tributaries contributed the lowest annual loading of phosphorus to Partridge Lake (8% or 5.99 Kg).

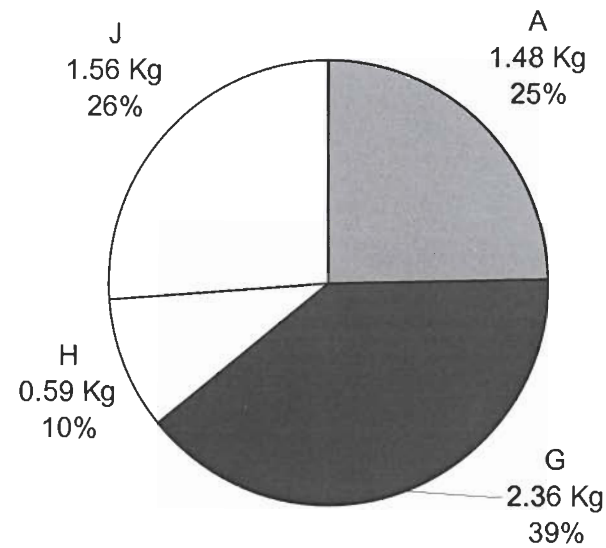
Table 3-3
Partridge Lake Average Tributary Total Phosphorus Concentrations (μg/L)

Tributary	Mean Concentration	Median	Standard Deviation	Phosphorus Loading (Kg)	% of Total Tributary Loading
A	10	7	5	1.48	25%
G	16	13	8	2.36	39%
H	9	8	4	0.59	10%
J	10	7	9	1.56	26%
Outlet	15	12	9	*	*

Tributary G contributed the highest phosphorus load of all measured tributaries in the watershed (2.36 Kg and 39% of the total phosphorus from gauged tributary loads). Tributary J contributed the second highest loading of phosphorus of the tributaries that were monitored during the study, with 1.56 Kg P and 26% of the tributary loading. Tributary A had mean annual stream Total Phosphorus concentrations of 10 ug/L, which was the second highest tributary phosphorus concentration, and contributed the third highest loading of this nutrient (1.48 Kg TP and 25%). Tributary H had the lowest mean annual concentration of total phosphorus (9ug/L), as well as the lowest mass loading of phosphorus to the lake of those tributaries studied (0.59 Kg TP and 10%).

Figure 3-2 shows the breakdown of contributions from the various tributaries and subwatersheds around Partridge Lake.

Figure 3-2
Partridge Lake Runoff Phosphorus Contributions

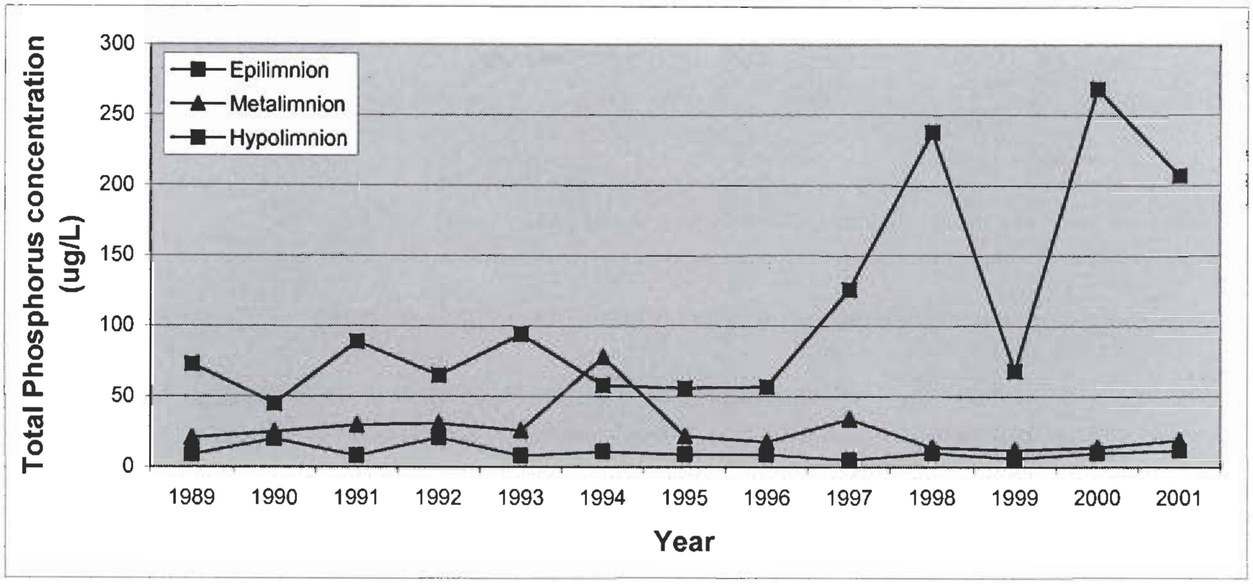


3.3.5 Internal Phosphorus Loading

The internal phosphorus load to Partridge Lake is considered significant during certain times of the year. Over the course of the summer during lake stratification , oxygen becomes depleted below 5 meters . During stratification, the hypolimnetic concentration of phosphorus increased greatly , reaching over 200 ug/L in most sampling events during the summer of 2000. Figure 3-3 shows hypolimnetic phosphorus trends since Partridge Lake joined the VLAP program in 1989. The hypolimnetic phosphorus concentration has been consistently higher than the epilimnetic concentration, and has been in the category of 'excessively high' according to DES rating categories.

This internal loading of phosphorus contributed an estimated 118.13 Kg of total phosphorus to Partridge Lake during the study year. This is more than the four watershed sources of phosphorus contributed over the course of the year.

Figure 3-3
Historical In-Lake Total Phosphorus Trends



3.4 Total Phosphorus Exports

There are two natural ways that total phosphorus can be removed from a lake system; either through out-flowing water from the outlet or through groundwater recharge from the lake. The remainder of the phosphorus remains in the system, cycling between the organic and inorganic phases by accumulating in the sediments, being taken up by bacteria, plants and algae, then cycling through the food web.

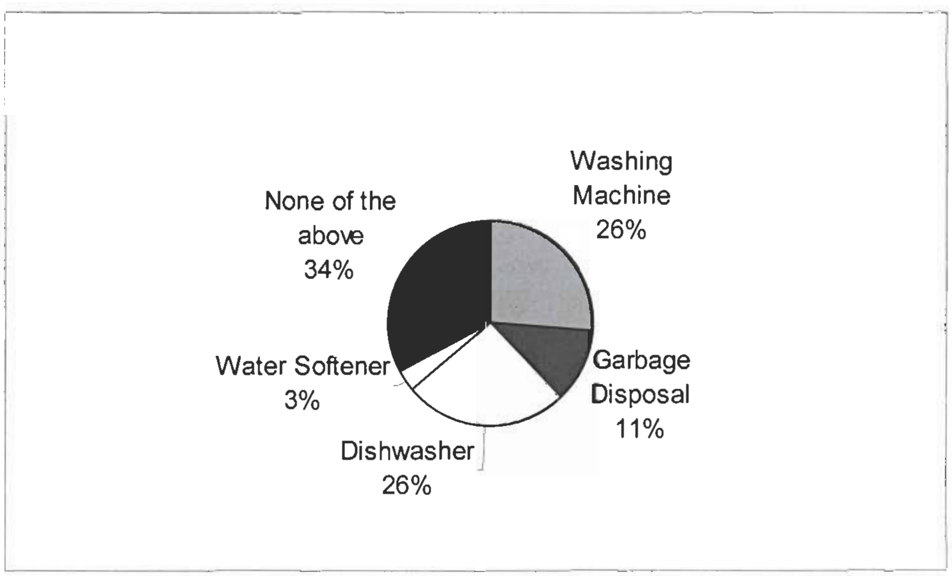
Over the course of the study year approximately 13.37 Kg TP was lost through out-flowing water over the spillway of the lake. The remaining 300.61 Kg TP was retained in the system, with some possibly leaving through groundwater recharge (which was not measured in this study).

3.5 Results of Anonymous Septic System Survey

An anonymous septic system survey was conducted of the Partridge Lake shoreline and watershed residents during the summer of 2001. Septic system condition is often a controversial topic around lakes, especially since a lot of systems are aging or inadequate. Some individuals feel uncomfortable admitting the state of their septic system, and likely would not respond when asked to provide their name with the information about their system, others simply do not know where their waste products end up . As a result, the septic survey was conducted in an anonymous manner so as to obtain at least a representation of the current conditions of the majority of systems in the vicinity of Partridge Lake. A copy of the septic system survey is included in Appendix 3. Approximately 77 anonymous surveys were mailed, and 42 completed responses were received. The return rate was 55%. The following discussion summarizes the results that were received.

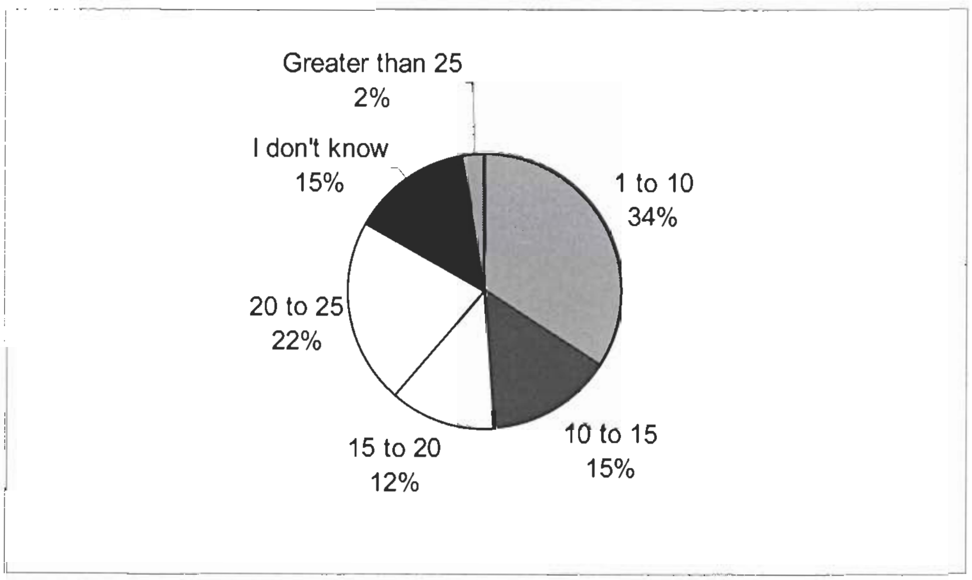
According to the returned surveys, 29% of the people responding to the survey represented year-round homes on the lake, and 71% represented seasonal cottages. This is significant because the septic systems of seasonal cottages should be upgraded when cottages are converted to year-round dwellings. With today's high volume water using machines (dishwashers, garbage disposals, water softeners, and washing machines), septic systems ultimately receive higher volumes of water and waste than originally intended. Of those responding to the survey, one quarter (26%) have washing machines, 26% have dishwashers, and 11% have garbage disposals. Only three percent had water softeners. Encouragingly, over 1/3 of those responding indicated they had none of these water using devices. While laws have banned the use of phosphates in household cleaning products, the law did not address automatic dishwasher detergents which contain very high phosphorus percentages. Figure 3-4 depicts the breakdown of common water-using devices in nearshore homes.

Figure 3-4
Percent of Homes/Cottages with Water Using Devices



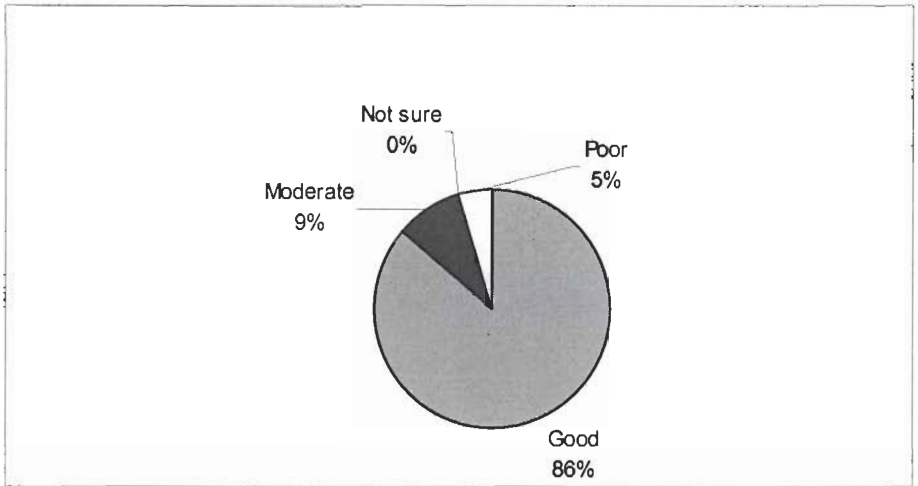
The approximate age of septic systems around the lake ranged from less than 5 years old to greater than 25 years old. The estimated life span of a state approved septic system is between 15 and 20 years, providing that the system is used within the design specifications. Thirty-four percent of those responding to the survey said their septic system was less than 10 years old. Fifteen percent said their system was between 10-15 years, 12% between 15-20 years, 22% between 20-25 years, and 2% were greater than 25 years old. Fifteen percent of the responders said that they did not know the age of their septic systems. In the evaluation of these results, approximately 36%, or just over one-third, of the responders indicated that their septic systems had reached or exceeded the estimated normal life expectancy for approved systems. Figure 3-5 summarizes the responses from the survey questions.

Figure 3-5
Age of Sewage Disposal System



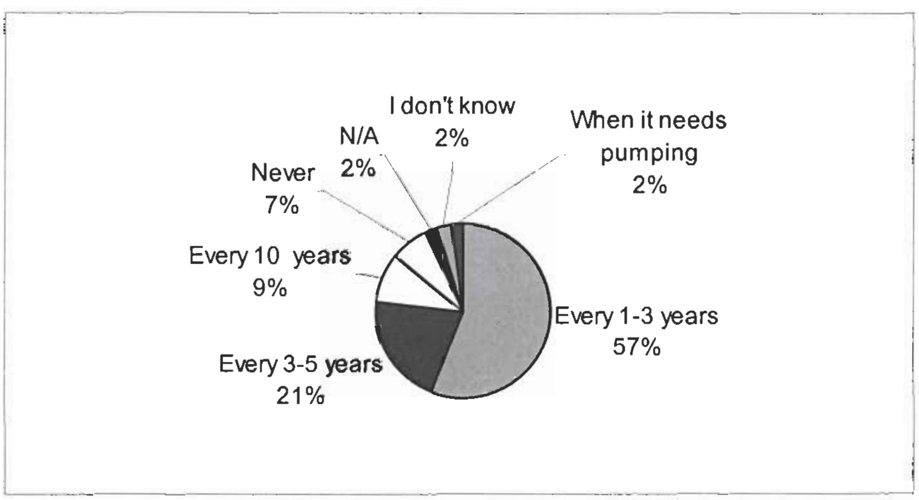
To determine the perceived health of the systems, the participants in the survey were asked to rate the condition of their septic system. Figure 3-6 summarizes the responses to this question. Eighty-five percent of those responding believed that their system was in good condition. Nine percent indicated that their septic system was in moderate condition, and only 5% indicated that their septic system was in poor condition. When asked if they have experienced problems with their system, everyone that participated in the survey indicated that they did not have problems with their system.

Figure 3-6
Perceived Condition of Sewage Disposal System



To alleviate problems, and to intercept a problem before it occurs, it is recommended that those living along the lake edge have their systems pumped and inspected every one to three years. Beyond the tier of cottages and homes immediately along the lake edge, it is recommended that residents pump their systems every 5 years. During pumping, the service person can inspect the system for any problems, and determine loading to the system. Referencing Figure 3-7, encouragingly, over half (57%) of those responding to the survey indicated that they have their system pumped every 1-3 years. Twenty-one percent have their system pumped every 3-5 years, nine percent every 10 years, and only 7% have never had their system pumped.

Figure 3-7
Frequency of Pumping for Sewage Disposal Systems



3.6 In-Lake Phosphorus Concentrations

Phosphorus is an essential element for plant growth and is the limiting nutrient that regulates the productivity of New Hampshire lakes. Much effort in controlling lake eutrophication has been directed toward controlling the phosphorus load to a lake. Unacceptable levels of phosphorus are often associated with human activities, and it appears that in most cases the removal or reduction of phosphorus load to a lake will lower algal productivity in lakes. NHDES has observed this result at both Beaver Lake ,Derry and Kezar Lake, North Sutton. The total phosphorus range for the summer epilimnetic values for New Hampshire lakes ranges between <1 and 121 ug/L, with a median value of 12 ug/L. Table 3-4 lists Mean phosphorus concentrations for the in-lake station at Partridge Lake.

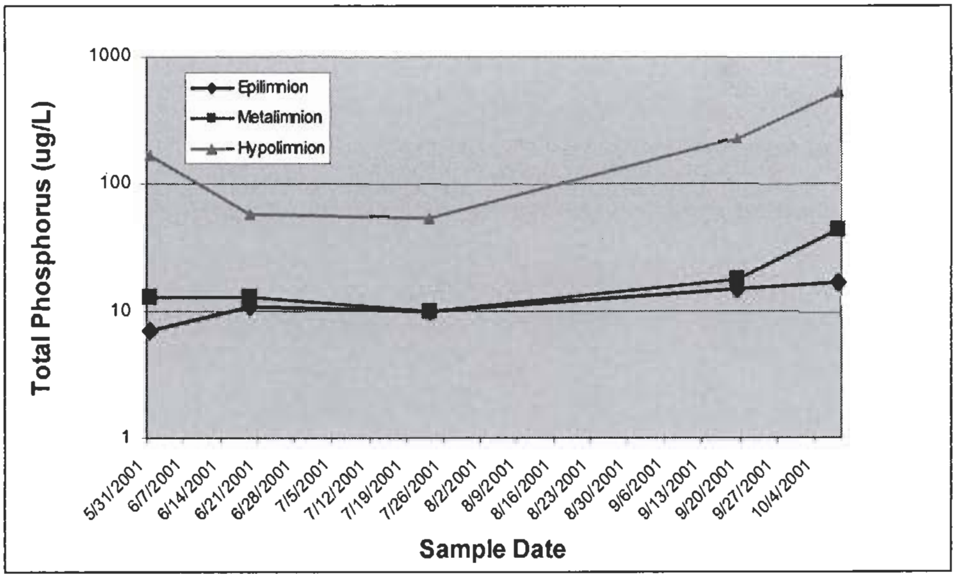
Table 3-4
Mean In-Lake Total Phosphorus Concentration (ug/L)

Sample Depth	Mean	Median	Standard Deviation
Epilimnion (surface layer)	12	11	4
Metalimnion (middle layer)	20	13	14
Hypolimnion (bottom layer)	293	228	149

The epilimnetic phosphorus concentrations of Partridge Lake falls within the 'mean' range for New Hampshire lakes and ponds (mean concentration of 12ug/L). Total phosphorus concentration in the metalimnion also fall within the mean range, with the mean concentration of 20 ug/L. The phosphorus in the bottom layer is considered 'excessive', with a summer mean phosphorus concentrations of 293 ug/L (greater than 40 ug/L is classified as excessive). There was a large degree of deviation in the bottom total phosphorus readings, due to the elevated phosphorus concentration measured late in the summer.

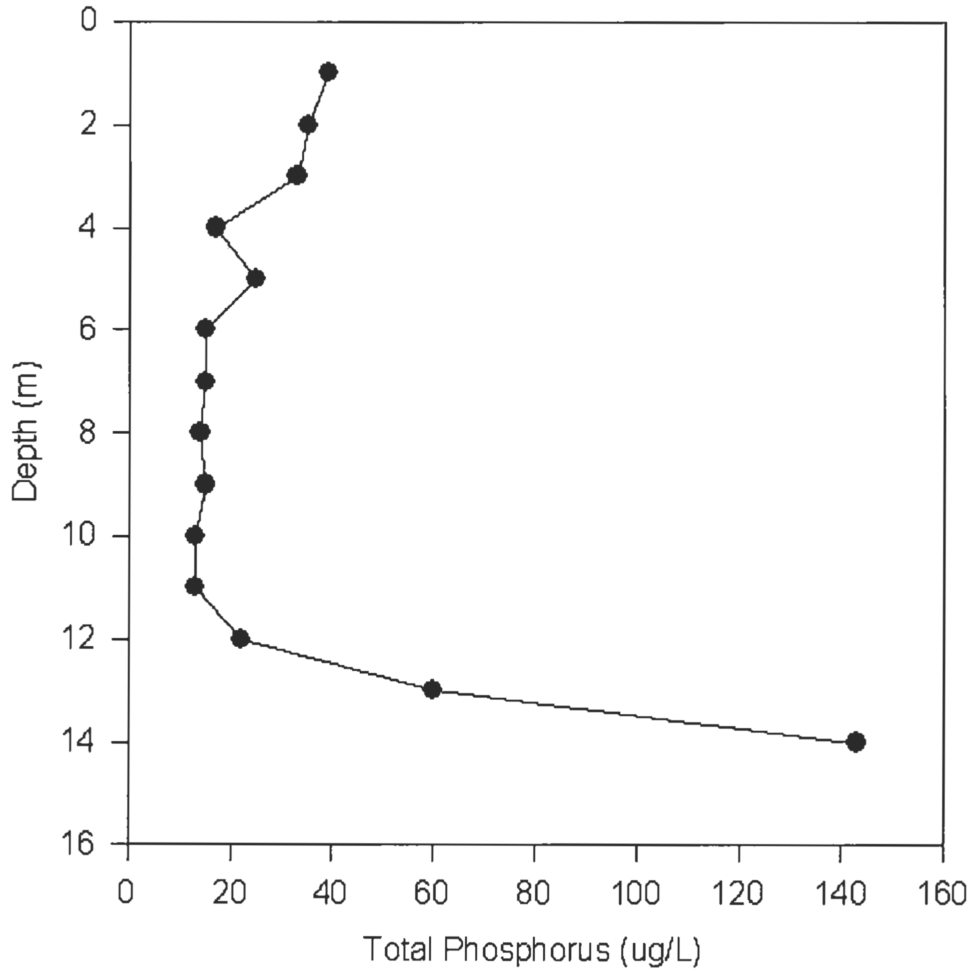
The data show that as the summer progresses, internal phosphorus loading from the bottom sediments is a major factor in the lake's nutrient budget. Internal loading occurs when the bottom of the lake loses oxygen, causing a chemical reaction in the sediments that ultimately results in the release of phosphorus to the water column. As the bottom waters lose oxygen during the summer months (according to the summer 1998 data), internal loading occurs. Figure 3-8 depicts in-lake total phosphorus concentration trends.

Figure 3-8
Partridge Lake Summer Total Phosphorus Trends (Log scale)



This internal loading process adds to the overall phosphorus available for algae growth in the lake, which is likely the cause of the occasional algae bloom that Partridge Lake has experienced in recent summers. Figure 3-9 illustrates a total phosphorus gradient in Partridge Lake on December 6, 2001. Even though the lake is fully mixed during this time of the year, as evidenced by a temperature profile, there is still an increase in total phosphorus in the bottom two meters. This may suggest that a chemocline, a chemical stratification layer, is present in the lake. The chemocline can be the result of a chemical gradient (likely sulfate in Partridge Lake) that is present despite the well mixed water column as evidenced by a fairly stable temperature profile (5.7°C to 6.2°C from 15m to 0.1m). The presence of a chemocline prevents full mixing of the water column so that elevated phosphorus concentrations persist throughout the year in the bottom layers.

Figure 3-9
Total Phosphorus Gradient in Partridge Lake on 12/6/01



3.7 Trophic Classification

Trophic classification through modeling allows biologists to determine the classification of a lake or pond based on a number of parameters. In the following cases, in-lake nutrient levels, oxygen levels, clarity, flushing rate, nutrient retention time and other factors are considered to gauge the current condition of Partridge Lake. The use of more than one model is important as the models differ on the parameters used to determine trophic classification. Trophic states of ponds can range within and between three basic categories: oligotrophic , mesotrophic, and eutrophic. Each of these terms is defined in the glossary of this report. Lakes and ponds and their trophic states are typically not static over time but rather are subject to the internal characteristics of the pond and especially the watershed that surrounds the pond.

Trophic classifications overall, however, do not typically change rapidly, unless the waterbody in question is very heavily impacted by point and non-point sources of pollution from the watershed. Most lakes can easily maintain the same trophic condition for hundreds of year. Unfortunately, some of our New Hampshire lakes have only recently experienced shifts in trophic condition due to uncontrolled developments in their watersheds, increased nutrient loads that create increased algal densities , and filling in the lake bottom with sediment and organic debris.

Following is a review of three models that were used to evaluate the trophic status of Partridge Lake.

3.7.1. State of New Hampshire Trophic Classification System

The classification system developed by the DES Biology Section (Table 3-5) utilizes four parameters, including dissolved oxygen concentration in the bottom layer of the lake, clarity, plant abundance, and the chlorophyll-a concentration of the water.

Table 3-6 presents the calculated value of each classified parameter for the 1979 and 2000 summer surveys of Partridge Lake. In 1979, Partridge Lake received a total of 9 trophic points, placing it within the mesotrophic range.

In 2001, it received 11 trophic points and was again classified as mesotrophic. Two more trophic points would have put the lake over the edge into the eutrophic category.

Table 3-5
Trophic Classification System for New Hampshire Lakes and Ponds

1. Summer Bottom Dissolved Oxygen:	**Trophic Points**
a. D.O. > 4 mg/L	0
b. D.O. = 1 to 4 mg/L & hypolimnion volume ≤ 10% lake volume	1
c. D.O. = 1 to 4 mg/L & hypolimnion volume > 10% lake volume	2
d. D.O. < 1 mg/L in < 1/3 hypolimnion volume & hypolimnion volume ≤ 10% lake volume	3
e. D.O. < 1 mg/L in ≥ 1/3 hypolimnion volume & hypolimnion volume ≤ 10% lake volume	4
f. D.O. < 1 mg/L in < 1/3 hypolimnion volume & hypolimnion volume > 10% lake volume	5
g. D.O. < 1 mg/L in ≥ 1/3 hypolimnion volume & hypolimnion volume > 10% lake volume	6
2. Summer Secchi Disk Transparency:	**Trophic Points**
a. > 7 meters	0
b. > 5 to 7 meters	1
c. > 3 to 5 meters	2
d. > 2 to 3 meters	3
e. > 1 to 2 meters	4
f. > 0.5 to 1 meter	5
g. ≤ 0.5 meter	6
3. Aquatic Vascular Plant Abundance:	**Trophic Points**
a. Sparse	0
b. Scattered	1
c. Scattered/Common	2
d. Common	3
e. Common/Abundant	4
f. Abundant	5
g. Very abundant	6
4. Summer Epilimnetic Chlorophyll-a (mg/m^3):	**Trophic Points**
a. < 4	0
b. 4 to < 8	1
c. 8 to < 12	2
d. 12 to < 18	3
e. 18 to < 24	4
f. 24 to < 32	5
g. ≥ 32	6

	Trophic Points	
Trophic Classification	Stratified	*Unstratified
Oligotrophic	0-6	0-4
Mesotrophic	7-12	5-9
Eutrophic	13-24	10-18

*Unstratified lakes are not evaluated by the bottom dissolved oxygen criterion.

Table 3-6
Trophic Classification of Partridge Lake Using NH Classification Methods

Trophic Classification – Summer 1979		
Parameter	**Value**	**Trophic Points**
Dissolved Oxygen	0.25 mg/L	5
Secchi Disk	5.0 m	1
Plant Abundance	Common	3
Chlorophyll-a	1.92 mg/m3	0
Classification : Mesotrophic		Total = 9
Trophic Classification- Summer 2000		
Parameter	**Value**	**Trophic Points**
Dissolved Oxygen	0.88 mg/L	5
Secchi Disk	5.31 m	1
Plant Abundance	Common/Abundant	4
Chlorophyll-a	4.45	1
Classification : Mesotrophic/Eutrophic		Total = 11

3.7.2 Dillon/Rigler Permissible Loading Model

Mathematical models can also be useful both in diagnosing lake problems and in evaluating potential solutions. They represent, in quantitative terms, the cause-effect relationships that determine lake quality. The Dillon/Rigler Model classifies a lake as oligotrophic, mesotrophic or eutrophic by comparing calculated annual loadings with permissible annual loadings. The tolerance of the lake to phosphorus loading is predicted as a function of two lake characteristics, mean depth (z) and water retention time (T), which has been proven by several researchers to be the primary determinants of loading permissibility.

Table 3-7 shows the relationship between these two lake characteristics.

Table 3-7
Dillon/Rigler Permissible Loading Tolerance

High Phosphorus Loading Tolerance	Low Phosphorus Loading Tolerance
Large mean water depth	Small mean water depth
Rapid flushing rate	Slow flushing rate
High P retention coefficient	Low P retention coefficient

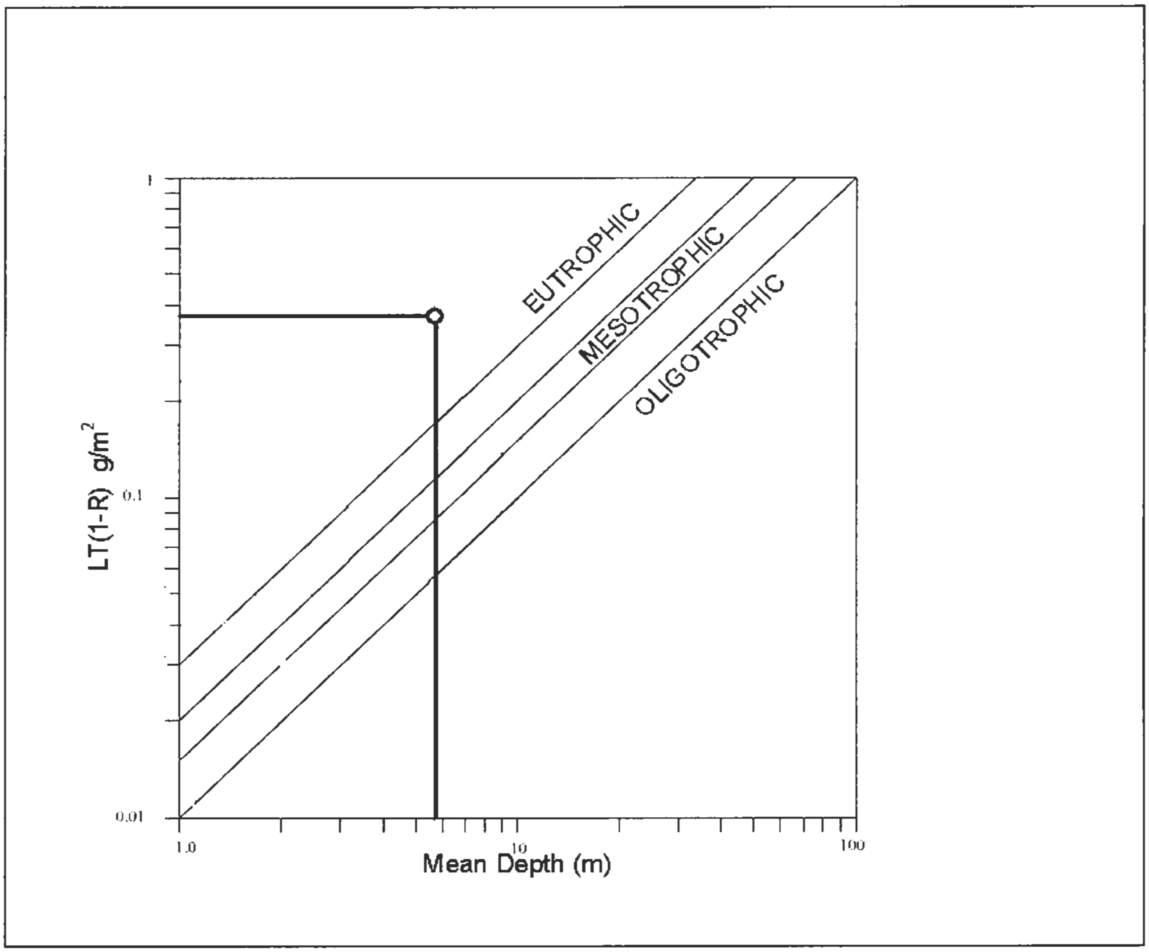
Thus, trophic status is set by existing values for these parameters and annual phosphorus loading. Table 3-8 presents the Dillon/Rigler trophic status calculations for Partridge Lake.

Table 3-8
Dillon/Rigler Trophic Status Calculations for Partridge Lake

Parameter	Calculation
Lake area (m^2)	420,500
Mean depth (m)	5.8
Total loading (kg)	195.85
Flushing rate (yr^{-1})	0.6
Water retention time (yr) (T)	2.86
P retention coefficient (R)	0.71
Total areal loading ($g/m^2/yr$) (L_p)	0.46
L_pT (1-R) (g/m^2) Where: L= Areal Phosphorus Load T= Water retention time (y) R= Phosphorus retention coefficient	0.387

Figure 3-10 is a graphical representation of the Dillon/Rigler model showing trophic zones, plotted on axes of mean depth and areal loading (Table 3-8) with the data point showing the trophic status of Partridge Lake. The solution of the Dillon/Rigler equation for Partridge Lake data shows the existing trophic status of the lake as borderline *eutrophic*. This trophic determination is based on the amount of phosphorus loading the lake receives.

Figure 3-10
Dillon/Rigler Model



3.7.3. Vollenweider Phosphorus Loading and Surface Overflow Rate Relationship

The Vollenweider model is based on a five-year study involving the examination of phosphorus load and response characteristics for about 200 waterbodies in 22 countries in Western Europe, North America, Japan and Australia (Vollenweider, 1975).

Vollenweider developed a statistical relationship between areal annual phosphorus loading (Lp) to a lake normalized by mean depth (Z) and hydraulic residence time (T), to predict lake phosphorus concentration (P). Table 3-9 summarizes the Vollenweider model parameters for the

Partridge Lake sample year.

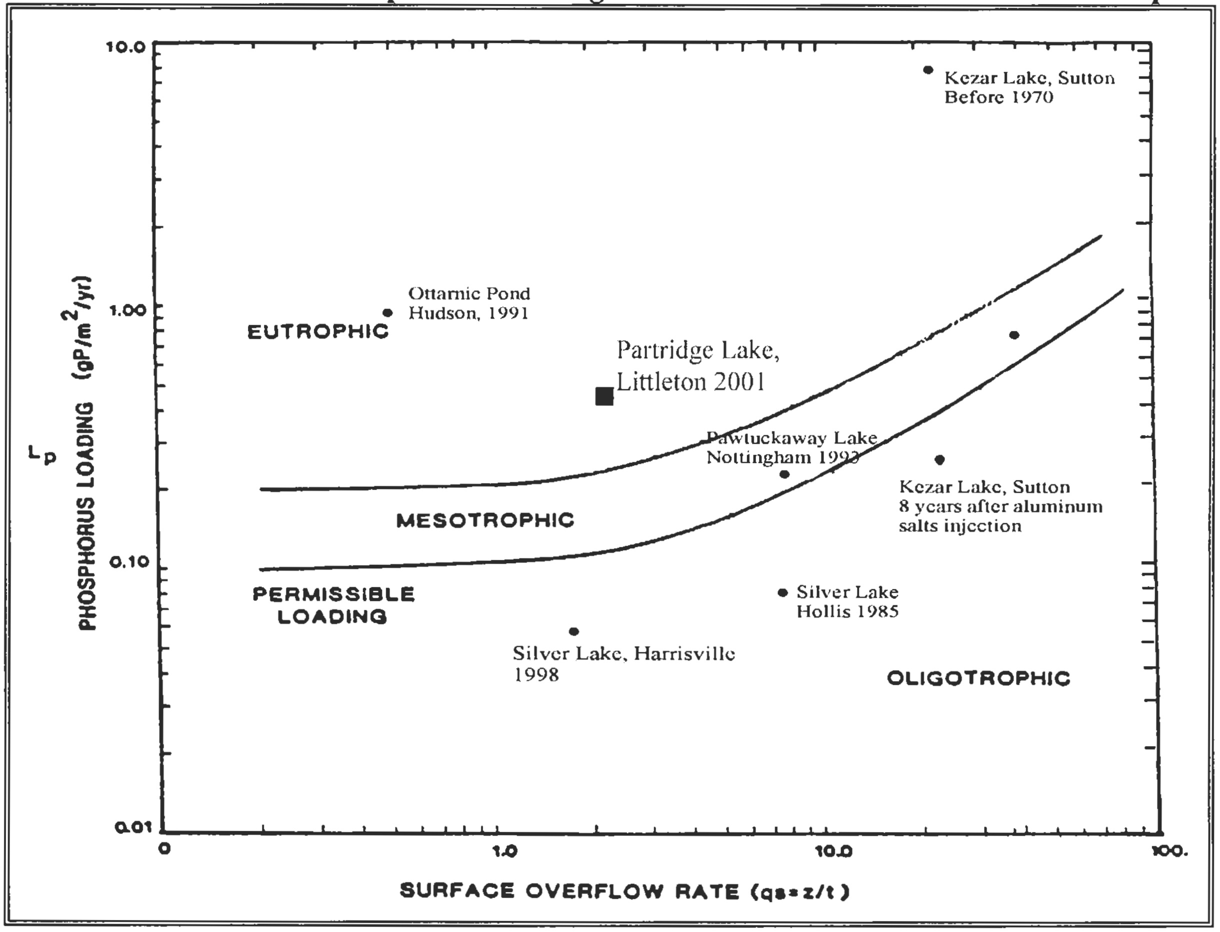
Table 3-9
Vollenweider Phosphorus Concentration Prediction

Parameter	Equation	Partridge Lake
1. Hydraulic residence time (T)	$T = \frac{V}{Q}$	2.86
2. Surface overflow rate (qs)	$qs = \frac{z}{T}$	2.02
3. Areal phosphorus load (Lp)	$Lp = \frac{P\,load}{lake\ surface\ area}$	0.46
4. Mean depth (Z)	measured	5.8m
5. Phosphorus concentration prediction (P)	$P = \frac{Lp}{qs}\left[\frac{1}{1+\sqrt{\frac{z}{qs}}}\right]$	0.465

Where V=lake volume, Q=lake discharge, z=mean depth, Pload= P loading as determined in this study

Figure 3-11 graphically portrays the measured loading rates for Partridge Lake and compares Partridge Lake with other New Hampshire Diagnostic/Feasibility studies.

Figure 3-11
Vollenweider Phosphorus Loading and Surface Overflow Rate Relationship



Based on the calculations, it can be seen that Partridge Lake falls within the *eutrophic* classification according to the Vollenweider model.

3.7.4 Trophic Classification Summary

A summary of the three classification schemes utilized in this study (Table 3-10) shows that the New Hampshire lake classification system classifies Partridge Lake as mesotrophic. The Dillon/Rigler model classifies the lake as eutrophic, as does the Vollenweider Phosphorus Loading model.

Table 3-10
Partridge Lake Trophic Classification Summary

Classification Model	Trophic Status
1. New Hampshire Lake Classification	Mesotrophic
2. Dillon/Rigler	Eutrophic
3. Vollenweider	Eutrophic

It is imperative to continue to monitor inflowing sources of water and to manage watershed areas with a conscientious effort because they are capable of changing the trophic class of the lake. The key is to prevent excess nutrient loading from impacting the lake, which will be discussed in more detail in Chapter 5.

4.0 AQUATIC ECOLOGY

4.1 In-Lake Data

4.1.1 Temperature and Dissolved Oxygen

Temperature is measured to determine the degree of lake stratification. In the summer months the surface water temperatures rise. Since this water is less dense (or lighter), it floats on top of the cooler, heavier water below. Swimmers may have noticed this occurrence when diving deep into the lake and encountering cool water.

Because of density differences, these layers do not mix throughout the summer. Each layer, including a middle layer of rapidly changing temperatures (the metalimnion/thermocline) is physically, chemically and biologically different than the other two. This layering breaks up in the fall when the top layer cools and begins a circulation process. With the formation of a solid ice layer another winter inverse stratification occurs under the ice, followed by another full mixing of the entire water column after ice out in the spring. Warmer temperatures begin the formation of a new lake stratification, usually leading to a thermally stratified lake by mid to late May.

Stratification, or layering, is typical for a lake with the size and depth of Partridge Lake. Summer temperatures near the surface for the study period averaged approximately 70° F, and bottom temperatures averaged approximately 43° F.

Oxygen concentrations are very important to the chemical and biological processes that take place in the lake. Oxygen enters a lake from the atmosphere and from wind and wave action. Plants in the lake also produce oxygen. Fish, insects, and other organisms rely on oxygen for their survival. For example, bacteria use up oxygen at the bottom of the lake as they break down organic material. Because of summer stratification, new oxygen from the atmosphere cannot be mixed to the bottom of the pond to replenish the supply. Decreased oxygen lower in the water column can result in decreased fish habitat in a lake. Decreases in oxygen also result in a process called internal loading, which is the release of phosphorus, a limiting nutrient from the sediments into the overlying water, thereby enriching the lake from within.

In-lake oxygen profiles were sampled once per month from June through September 2000. Partridge Lake showed signs of declining oxygen concentrations below 5 meters as the summer progressed, where oxygen concentrations reached nearly 0 mg/L. Even in the early part of the summer (May and June), oxygen was depleted in the lower depths. This continued into July, with the lowest readings occurring in August and September.

This continued trend in low oxygen concentrations is due to the accumulation of organic matter in the lake bottom, providing plenty of food for oxygen-using bacteria. Decaying plant material, algae, leaf litter, animal waste products, and debris from the surrounding watershed all contribute to the accumulation of organic material in the bottom of the lake. These are all natural processes, but activities in the lake's watershed, like tree clearing, lawn fertilizing , increasing impervious areas from development, and leaking septic systems can accelerate the accumulation.

Temperature and oxygen profiles and raw data can be found in Appendix 4.

4.1.2 pH And Acid Neutralizing Capacity (ANC)

The pH scale ranges from 0 – 14 units with a pH of 7 units being a neutral value. "Pure" water has a pH of 7 units. Most New Hampshire lakes are slightly acidic, with pH values between 6 and 7 units. When the pH falls between 6.0 and 5.5 units, the waters are considered endangered. Lakes with pH units of 5.4 to 5 are considered in the critical range, and below this point, lakes are considered acidified. Table 4-1 summarizes the true mean and median pH of Partridge Lake during the summer of 2000.

Table 4- 1
In-Lake True Mean and Median pH Values for Summer 2000

Sample Depth	Mean	Median	Standard Deviation
Epilimnion (surface layer)	7.33	7.33	0.12
Metalimnion (middle layer)	6.58	6.57	0.02
Hypolimnion (bottom layer)	6.59	6.6	0.02

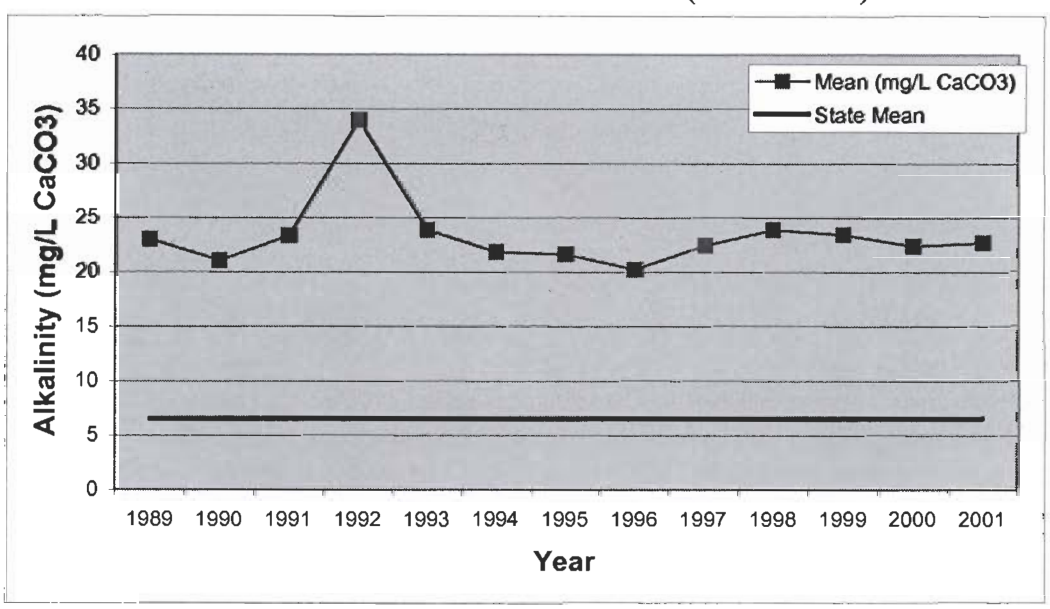
The true mean pH of the epilimnetic waters was slightly above neutral during the summer of 2000 sampling period, meaning that the upper layer of the lake is slightly basic. The pH decreased slightly with increased depth in the lake, dropping to pH 6.58 in the middle layer. The bottom layer of the lake was similar to the middle layer, at pH 6.59. The pH of lakes is typically lower at the bottom due to microbial activity and other chemical processes.

The waters of Partridge Lake would fall within the 'satisfactory' category, meaning that the lake is neutral. When the pH of a waterbody becomes too low, fish, insects, and other aquatic life can be threatened. For the most part, the pH of Partridge Lake has remained within the same range since 1989, when the lake association began monitoring Partridge Lake with the Volunteer Lake Assessment Program (VLAP).

The Acid Neutralizing Capacity (ANC) is the capacity of water to neutralize acid inputs. This concept is much like the use of an antacid tablet to buffer acid reflux in the stomach. New Hampshire lakes are generally low in ANC (ranging from 2 to 20 mg/L of $CaCO_3$). This is due in part to the State's granite bedrock, which contains few of the compounds that buffer acids (like calcium). As a result, New Hampshire lakes have a poor buffering capacity, and thus are more susceptible to acid rain than lakes with a higher acid neutralizing capacity. Acid neutralizing capacity was only measured in the upper water layer.

The mean ANC value for the epilimnion of Partridge Lake during the 2000 study year was 22.4 mg/L (median of 22.7 mg/L) as calcium carbonate. This places the lake within the 'not sensitive' category to acid additions. This means the lake is able to effectively buffer against acid additions from precipitation and runoff. This reading is much higher than the mean of lakes and ponds in New Hampshire (epilimnetic mean of 6.4 mg/L as calcium carbonate). Figure 4-1 shows the trend in epilimnetic ANC levels in Partridge Lake over time.

Figure 4-1
Historical Trends in In-Lake ANC Levels (from VLAP) data



4.1.3 Conductivity

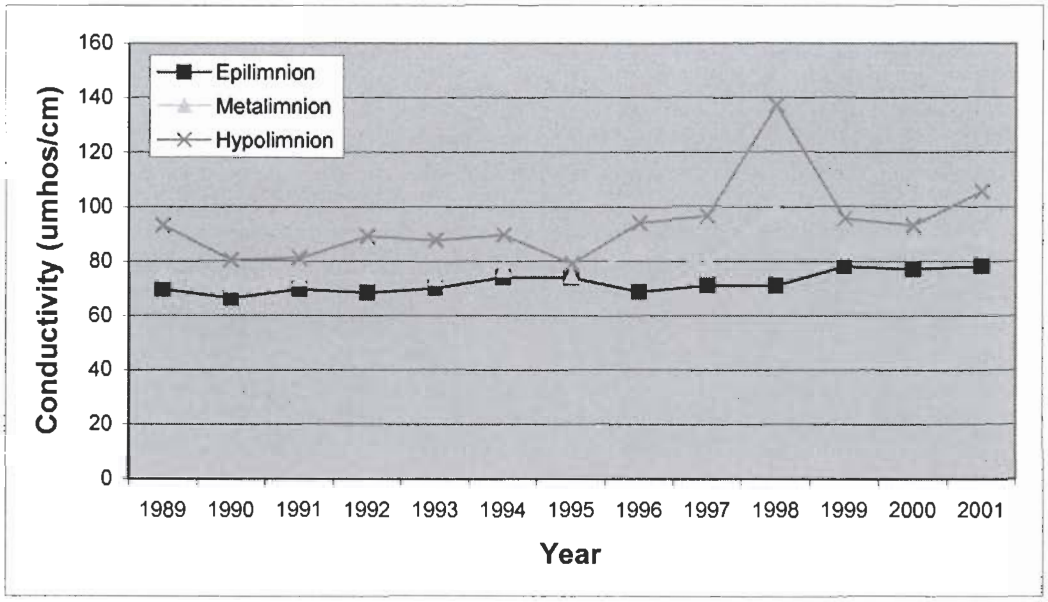
Specific conductance (conductivity) is a measure of the capacity of water to conduct an electrical current. The soft waters of New Hampshire generally have a low conductance relative to highly mineralized waters found in some parts of the country. The conductance of water is related to the presence of dissolved solids, such as salts and metals, and thus is usually higher in sewage and heavily impacted areas than in natural waters. Table 4-2 summarizes the mean conductivity values of Partridge Lake. The mean conductivity for New Hampshire lakes and ponds is 56.8 umhos/cm.

Table 4-2
Summer 2000 In-Lake Mean Conductivity Values (μmhos/cm)

Sample Depth	Mean	Median	Standard Deviation
Epilimnion (surface layer)	77.21	76.84	0.81
Metalimnion (middle layer)	87.07	86.26	2.24
Hypolimnion (bottom layer)	95.51	93.38	4.88

The mean conductivity values for Partridge Lake are higher than the mean for New Hampshire lakes and ponds. Anthropogenic activities, such as land use practices, old and failing septic systems, road salting, and fertilizers may contribute to these higher-than-mean levels. Also, this area along the Connecticut River has higher than mean ANC, due to soil and bedrock types. Higher ANC waters tend to have higher conductivity, even without human impacts, so there may be some natural contributions to the higher levels of conductivity at Partridge Lake. These in-lake mean levels show that conductivity is higher at the bottom of the pond where the salts and other metals accumulate. As shown in Figure 4-2, mean summer conductivity levels have not increased markedly over the years since Partridge Lake joined the VLAP program. Please consult your 2005 VLAP report for statistical trend analyses.

Figure 4-2
Historical In-Lake Conductivity Trends for Partridge Lake (from VLAP data)



4.1.4 Turbidity

Turbidity is caused by the presence of suspended particles of clay, silt, organic matter, and algal cells in the water. As light passes through the water, it is scattered, reflected or absorbed by these suspended particles. Erosion of watershed soils and the lake shoreline create high turbidity values, which are often highest during storm events. Also, high numbers of algae in the water column can contribute to higher turbidity. As these particles enter the lake they slowly fall through the water column and accumulate at the bottom of the lake. Table 4-3 summarizes the mean turbidity levels in each layer of Partridge Lake.

Table 4-3
Summer 2000 In-Lake Mean Turbidity Levels (NTU)

Sample Depth	Mean	Median	Standard Deviation
Epilimnion (surface layer)	0.44	0.46	0.05
Metalimnion (middle layer)	0.51	0.53	0.06
Hypolimnion (bottom layer)	2.55	2.70	1.73

The mean turbidity values show that the suspended sediments increased closer to the bottom of the lake. In some lakes, bottom sediments are loose, or flocculent, and can easily become resuspended in the water column because of currents or disturbance from wind or boat engines.

Mean epilimnetic and metalimnetic turbidity values for Partridge Lake during the 2000 summer period were lower than the NH VLAP mean of 0.8 NTU for the lakes in that program. The mean hypolimnetic turbidity levels were higher than the NH VLAP mean summer levels (1.0 NTU) during 2000; though the range of the samples varied considerably. It is conceivable that one or two of the readings skewed the mean. Overall, however, lake turbidity levels remain low.

4.1.5 Algae

Algae, or phytoplankton, are the microscopic plants that are free-floating in the water column of the lake. Algae, like plants and trees, photosynthesize. They use energy from the sun along with nutrients and carbon dioxide from the water, to produce both their food source (carbohydrates) and oxygen, which is released to the water.

Algae are a necessary component in any waterbody. These small plants are consumed by microscopic animals (zooplankton), aquatic insects, tadpoles, crayfish, fish, and other organisms. The algae are the primary producers and base of the aquatic food web.

Varying water quality conditions can influence the growth or abundance of algae. Typically, when a waterbody is rich in nutrients it is also abundant in algae. Oftentimes algal blooms can occur, including those caused by nuisance cyanobacteria (that turn the water bluish-green), green algae, diatoms, and golden brown algae.

Because algae are for the most part free-floating (some, like the cyanobacteria can control their location in the water column by regulating their cell buoyancy) blooms may occur only in portions of a waterbody and not in others. Wind, currents, and morphological characteristics of waterbodies can dictate the location of blooms.

The top three dominant genera of the summer 2000 plankton analyses are listed in Table 4-4. A mix of diatoms, golden brown algae and dinoflagellate algae represent the Partridge Lake algal community. The golden-brown algae were typically dominant, with *Dinobryon* as the most abundant species throughout the summer.

Table 4-4
Results of Microscopic Analyses for Algae from Summer 2000

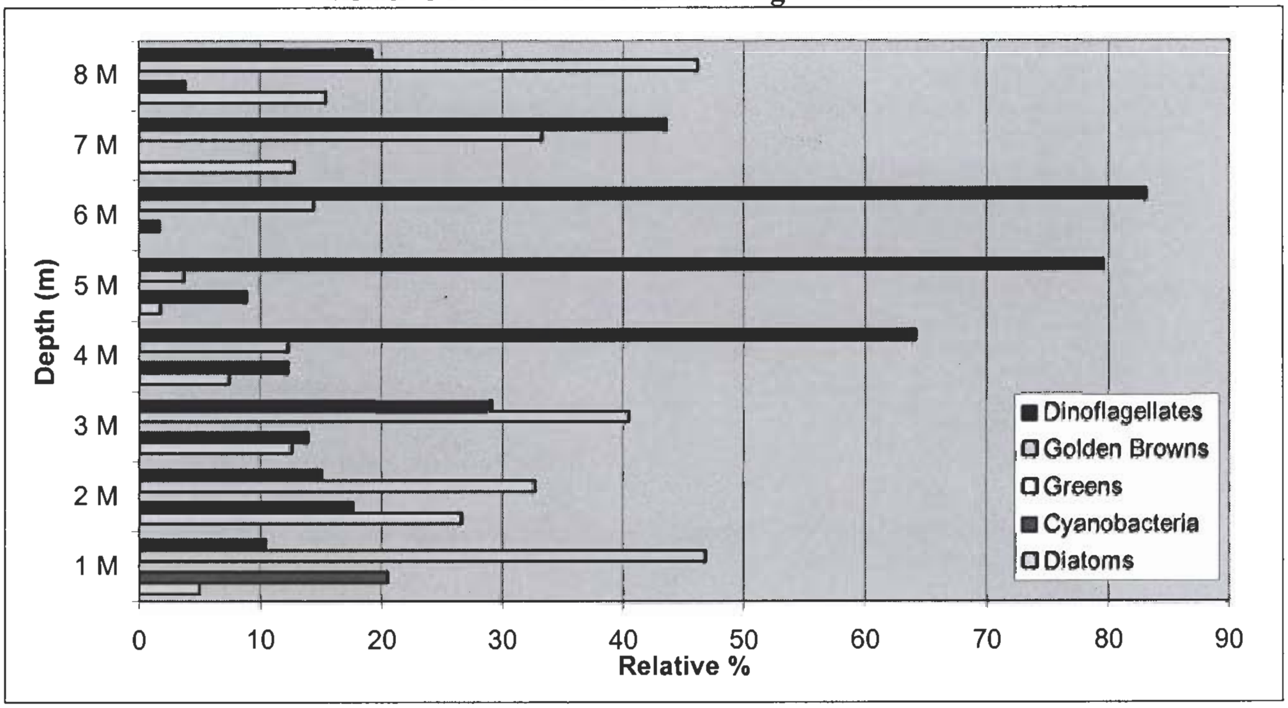
Date	Species	Algal Groups	Relative Abundance (%)
7/31/2000	*Dinobryon*	Golden Brown	82
	Staurastrum	Green	6
	Fragilaria	Diatom	5
8/21/2000	*Dinobryon*	Golden Brown	71
	Schroederia	Green	10
	Ceratium	Dinoflagellate	9
9/19/2000	*Dinobryon*	Golden Brown	41
	Ceratium	Dinoflagellate	17
	Chrysosphaerella	Golden Brown	11

Although cyanobacteria were not one of the top three dominant algae, as listed in Table 4-4 above, cyanobacteria blooms have become a seasonal problem in Partridge Lake. A depth discriminant analysis of the algal community was conducted during one summer of the study. Figure 4-3 summarizes the data collected from this special study. Dinoflagellate abundance increased steadily with depth, reaching nearly 85% abundance at 6 meters, and then dropped off quickly from 6m-8m in the water column. Golden brown algae started out with abundances ranging from roughly 35%-45% in the upper layers, dropped in abundance in the middle layers of the epi/metalimnion, and then slowly increased again to the 8m depth. For the most part diatoms ranged between 5% dominance to 15% dominance in the depth range that was sampled.

Cyanobacteria, the species of greatest interest, appeared to decline in abundance with depth. The cyanobacteria have the ability to regulate their depth in the water column due to gas vesicles that can be inflated or deflated by the algae. This species can grow undetected at lower depths and may not be observed until it blooms at the surface. It is not known if populations existed below the 8m mark as samples were not collected below the photic zone of the lake.

Green algae were not observed in the sampling.

Figure 4-3
Relative Percent of Dominant Algal Families



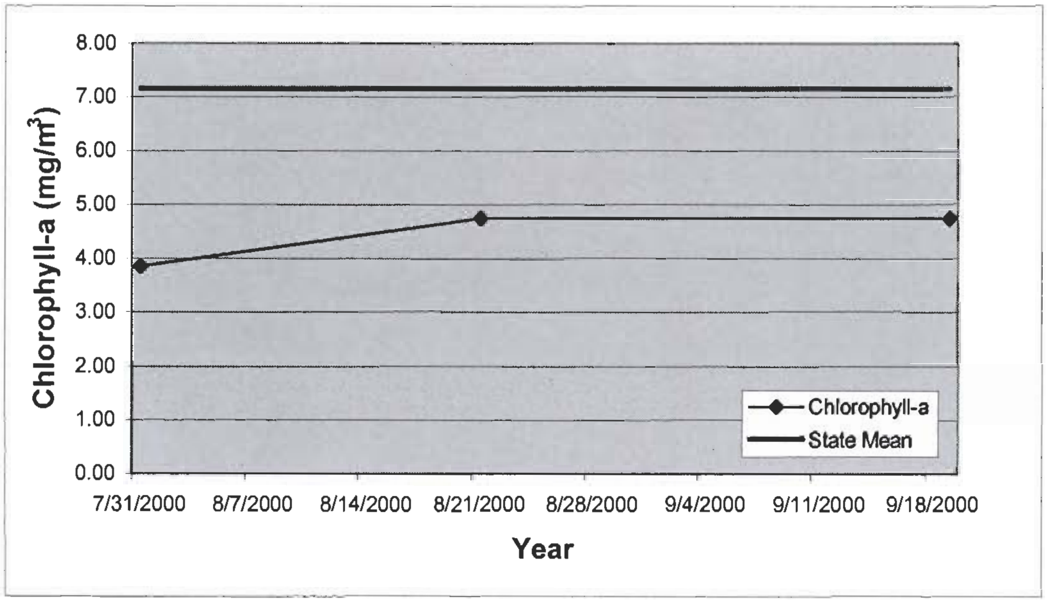
4.1.6 Chlorophyll-a

Chlorophyll-a is the measure of the amount, or density, of the green photosynthetic pigment in algal cells. Measuring chlorophyll-a gives biologists an indication of how much algae is in the water column at any given time. Figure 4-4 shows the trend in chlorophyll-a densities from July 2000 to September 2000.

The mean chlorophyll-a value for the summer of 2000 was 4.45 mg/m^3. Chlorophyll-a has not changed greatly in the lake over the years, but it has fluctuated, particularly from 1989-1992 and 1998-1999

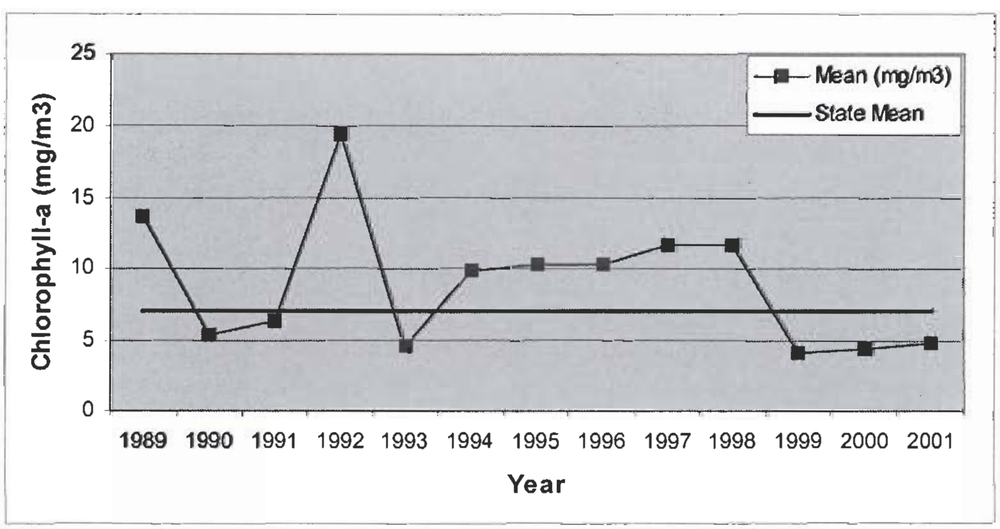
As a general rule for NH lakes and ponds, a range of 0-5 mg/m^3 is considered 'good' for algal abundance, and 5.1-15 mg/m^3 is more than desirable in a lake or pond. None of the chlorophyll-a measurements analyzed from Partridge Lake were other than in the 'good' category. Chlorophyll-a levels remained well below the nuisance range except for a 1992 elevated reading. During this study algal density did increase slightly as the summer progressed, likely due to ideal weather and nutrient conditions in the lake, but they did not approach nuisance levels.

Figure 4-4
Partridge Lake Chlorophyll-a Levels



Examining the historical trend in chlorophyll-a for the lake, overall algal density has not increased markedly since regular sampling began in 1989 and, in fact has shown a more stable trend over time, especially from 1994 to 1998 and from 1999 to 2001. Figure 4-5 shows the trend in chlorophyll-a concentrations in Partridge Lake. The cyanobacteria blooms are episodic in the lake, but have become more of an annual occurrence.

Figure 4-5
Historical Trends in Chlorophyll-a Concentrations (from VLAP data)



4.1.7 Transparency

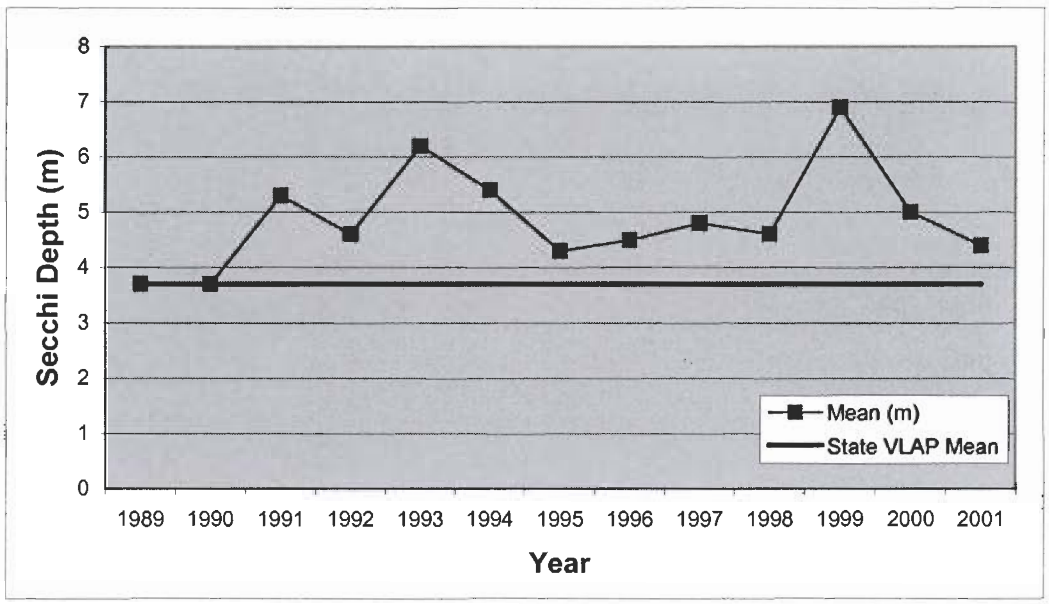
Transparency is a measure of water clarity. Algal growth, water color, suspended sediments, waves, and reflection on the water's surface influence water clarity.

Partridge Lake clarity is higher than the mean clarity of most lakes and ponds in New Hampshire. In 2000, the mean recorded clarity of Partridge Lake was 5.3 meters.

The first recorded transparency was 6.4 meters recorded in 1939 by the New Hampshire Fish and Game Department. The highest clarity reading was recorded by VLAP on August 26, 1999, with a clarity of 7.9 m.

Overall, clarity has fluctuated slightly since 1989 when Partridge Lake joined VLAP. Figure 4-6 shows the trend in mean annual lake clarity since 1989.

Figure 4-6
Historical Trends in Partridge Lake Clarity (from VLAP data)

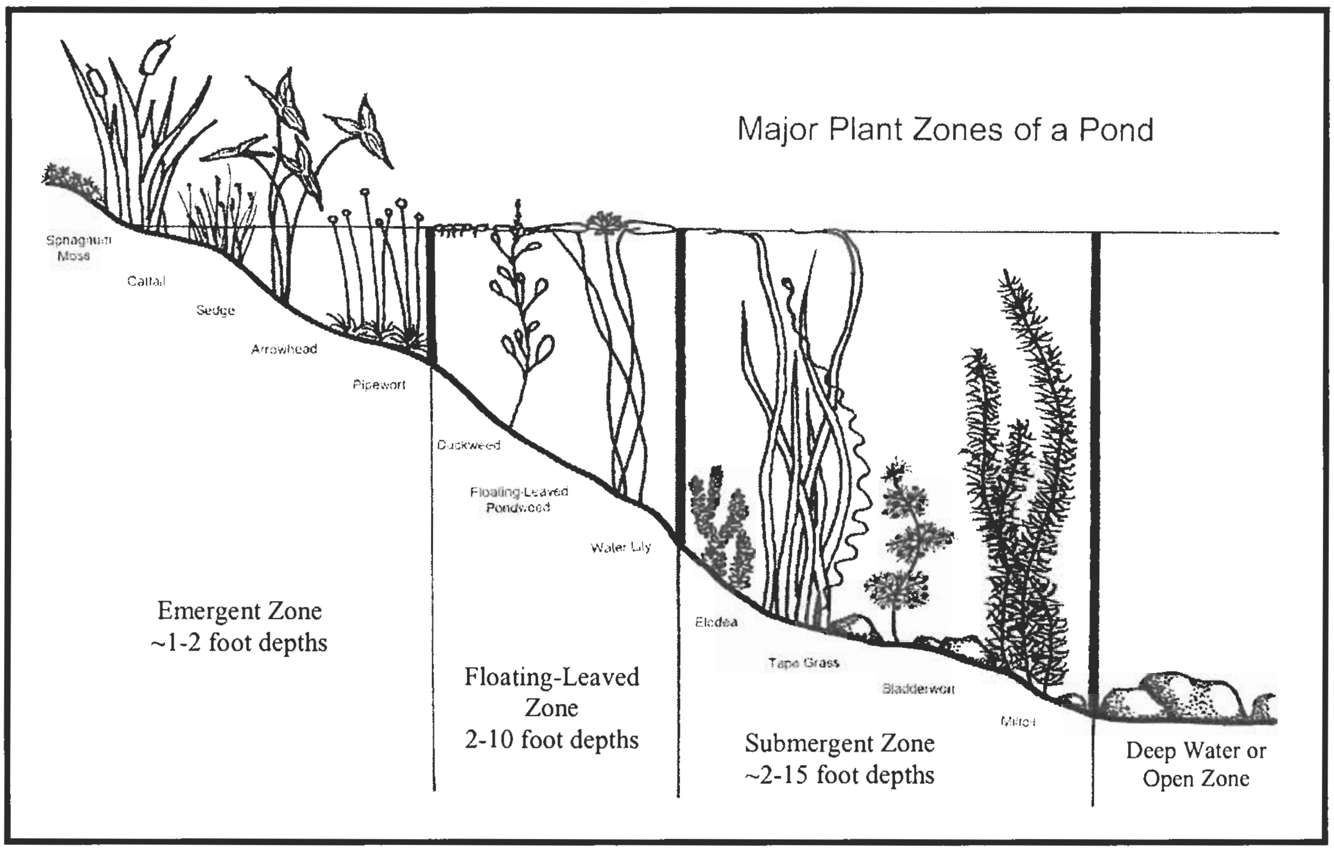


4.1.8 Aquatic Plants

Aquatic plants are another necessary component to a healthy aquatic environment. Aquatic plants provide deep rooting systems to stabilize lake beds and shorelines, a natural protection against erosion. These plants also provide surfaces on which algae grow, produce oxygen, provide food and nesting materials for many birds and aquatic organisms, and provide cooling shade to the lake bed. Most importantly, plants provide diverse above-water and below-water structure that many organisms need for habitat, especially fish. These plants can be emergent, submergent or floating. Figure 4-7 illustrates the approximated zonations of various common aquatic plants.

Aquatic plant surveys of Partridge Lake were conducted in 1979, 1992, and 2001. Figures 4-8a through 4-8c show the results of each year's plant survey. Tables 4-5a through 4-5c list the symbol, common name, and genus of each of the macrophytes identified during the plant surveys.

Figure 4-7
Aquatic Plant Zonations*



*Note: Actual depths at which these plants are found can vary considerably depending on water clarity, substrate type, and shoreline configuration.

Fortunately, Partridge Lake has been spared the impacts of nuisance growths of exotic plants like milfoil or fanwort, though nearby lakes and streams are affected by such exotics. It is recommended that the Weed Watcher Program be continued to monitor the lake for any possible introductions and infestations.

The plant community of Partridge Lake was represented by scattered lily populations, a few species of pondweed (most notably *Potamogeton robbinsii* and *Potamogeton amplifolius*), and various rushes and sedges. Scattered patches of the white button-like flowered pipewort were also found around the lake edge.

Figure 4-8a
Partridge Lake Plant Survey, Summer 1979

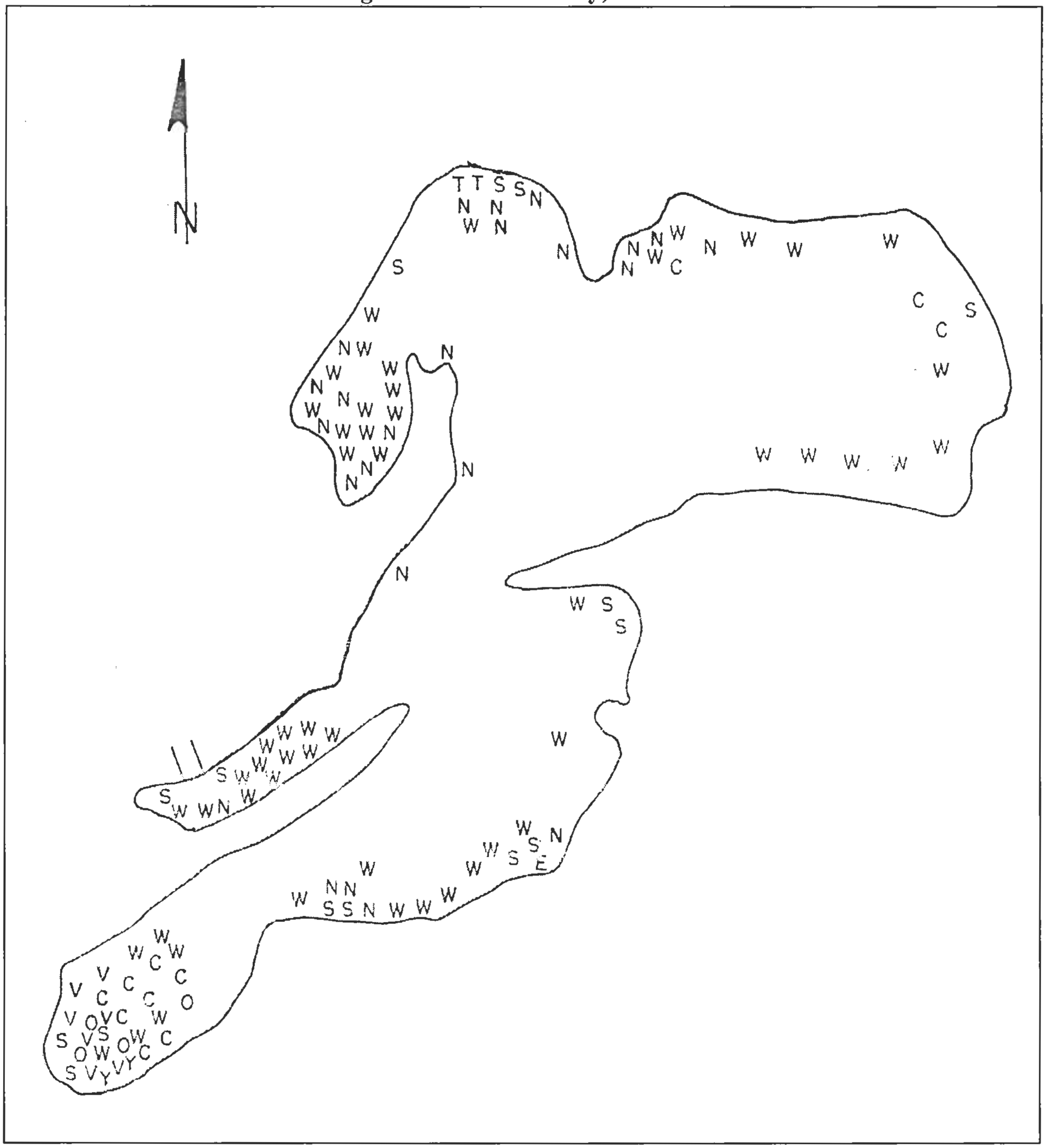


Figure 4-8b
Partridge Lake Plant Survey, Summer 1992

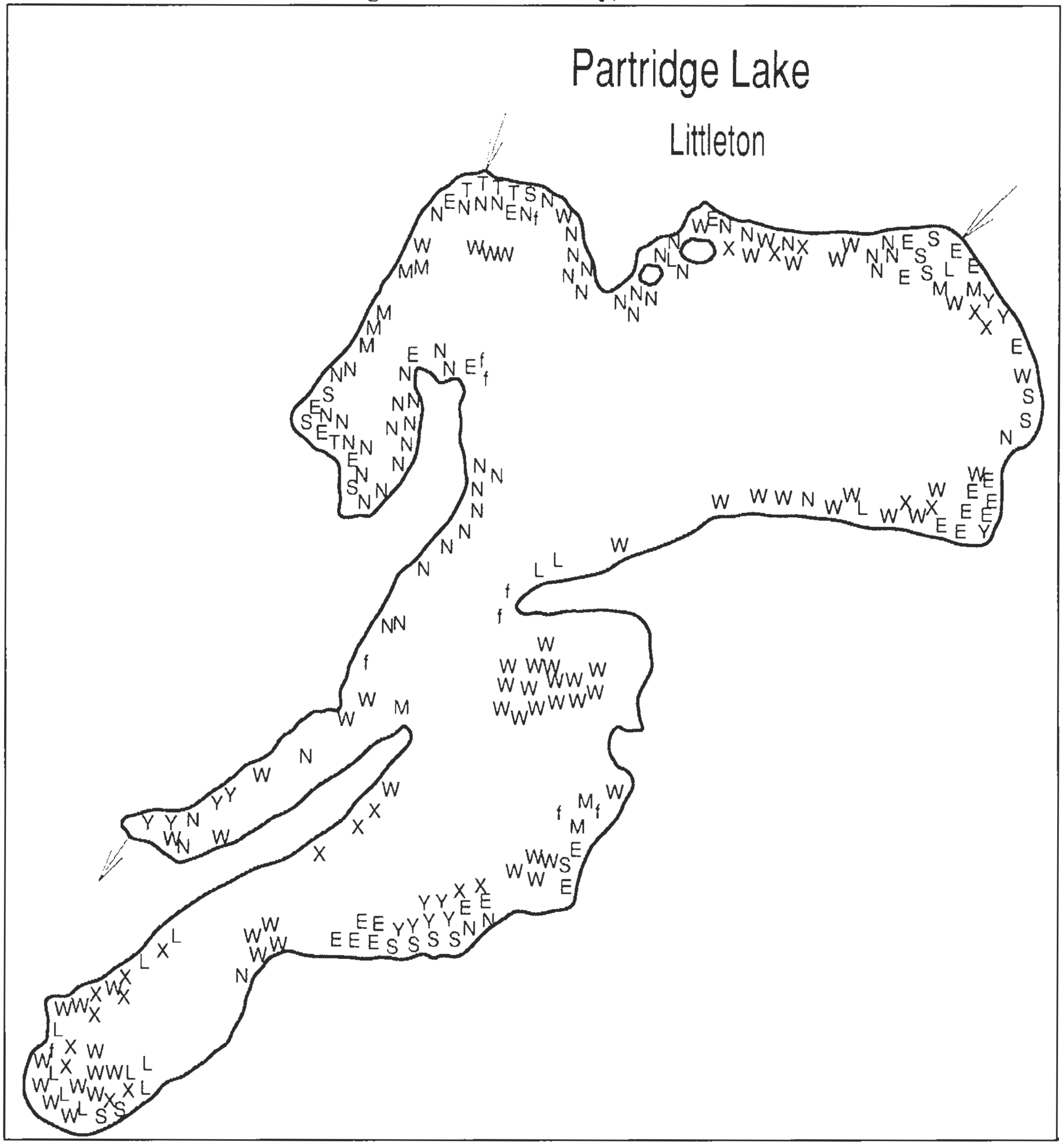


Figure 4-8c
Partridge Lake Plant Survey, Summer 2001

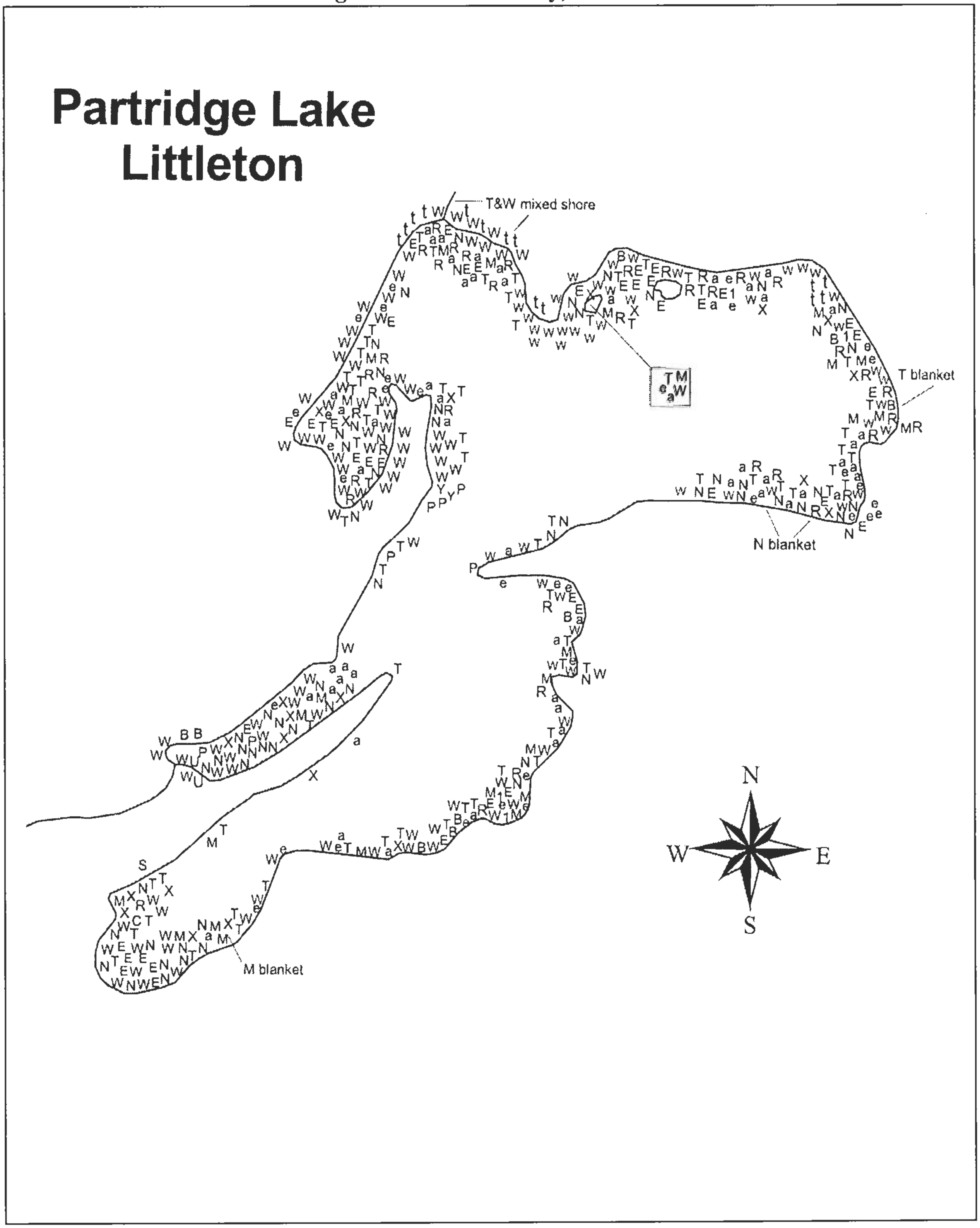


Table 4-5a
Partridge Lake Plant Survey, Summer 1979

Symbol	Latin Name	Common Name	Abundance
W	*Potamogeton*	Pondweed	Abundant
S	*Sparganium*	Bur-reed	Scattered
N	*Nymphaea*	White water lily	Scattered
C	*Ceratophyllum demersum*	Coontail	Common
Y	*Nuphar*	Yellow water lily	Sparse
T	*Typha*	Cattail	Sparse
E	*Eriocaulon septangulare*	Pipewort	Sparse
V	*Vallisneria Americana*	Tapegrass	Sparse
O	*Elodea*	Waterweed	Sparse

Table 4-5b
Partridge Lake Plant Survey, Summer 1992

Symbol	Latin Name	Common Name	Abundance
N	*Nymphaea*	White water lily	Scattered
Y	*Nuphar*	Yellow water lily	Sparse
W	*Potamogeton*	Pondweed	Scattered/Common
S	*Sparganium*	Bur-reed	Scattered
e	*Elodea nuttallii*	Waterweed	Scattered
E	*Eriocaulon septangulare*	Pipewort	Sparse
T	*Typha*	Cattail	Sparse
g		Bottom growth	Scattered/Common
f	*Chlorophyceae*	Filamentous green algae	Scattered
M	*Megalodonta beckii*	Water marigold	Sparse
X		Sterile thread-like leaf	Scattered/Common

Table 4-5c
Partridge Lake Plant Survey, Summer 2001

Symbol	Latin Name	Common Name	Abundance
N	*Najas*	Water naiad	Scattered
Y	*Nuphar*	Yellow water lily	Sparse
P	*Potamogeton*	Pondweed	Scattered/Common
1	*Sparganium aquaticum*	Bur-reed	Scattered
E	*Elodea*	Waterweed	Sparse
T	*Typha*	Cattail	Sparse
G		Bottom growth	Scattered/Common
F	*Chlorophyceae*	Filamentous green algae	Scattered
M	*Megalodonta beckii*	Water marigold	Sparse
F	*Nymphoides*	Floating heart	Scattered

W	*Nymphea*	White water lily	Common
T	*Vallisneria*	Tapegrass	Scattered
A	*Potamogeton amplifolius*	Bassweed Pondweed	Common
C	*Ceratophyllum*	Coontail	Sparse
S	*Hypericum*	St. John's Wort	Sparse
R	*Potamogeton robbinsii*	Robbins Pondweed	Common
U	*Potamogeton natans*	Common Pondweed	Scattered
X		Filamentous algae	Scattered/Common

4.2 Tributary Data

The following sections of this chapter will describe the results of the water quality data from the tributaries and the outlet of Partridge Lake collected from September 1999 through August 2000. Raw tributary data can be found in Appendix 5.

Unlike in-lake samples, there are no NH ranges or means calculated for water quality in tributaries. The ranges for lake quality will be loosely applied to the interpretation of data for tributaries.

4.2.1 pH

Tributary pH was monitored throughout the study period. Table 4-6 shows the mean pH values for each tributary in the Partridge Lake watershed.

Table 4-6
Partridge Lake Tributary True Mean pH

Tributary	Mean pH	Median	Standard Deviation
A	7.19	7.21	0.12
B	6.61	6.57	0.11
D	6.94	6.94	0.06
E	7.08	7.08	0
F	6.82	6.85	0.16
G	7.41	7.44	0.09
H	7.43	7.42	0.12
J	7.29	7.29	0.08
K	7.31	7.32	0.14
L	6.45	6.37	0.17
Outlet	7.38	7.40	0.13

The mean pH of lakes and ponds in NH is about 6.5 units (not true mean pH). The mean tributary pH values for Partridge Lake all fall above the state mean of almost 800 lakes and ponds, and are within the 'satisfactory' range for New Hampshire surface waters. When pH values fall below 6 units, these waters may become too acidified for some wildlife species. The pH of streams may be affected by acid rain, soil characteristics, land use patterns, photosynthesis and decaying plant materials.

The data show that the pH of the water leaving the lake is higher than the pH of the water entering the lake. As algae and plants in the surface waters of Partridge Lake photosynthesize they increase the pH of the surface water. For the most part, the water flowing out of the lake in the summer is representative of the pH in the upper layer of the lake.

4.2.2 Conductivity

Tributary conductivity values can be indicative of subwatershed pollution. When conductivity values in tributaries are elevated it can be the result of road salt runoff, fertilizer runoff, septic system inputs, land use patterns and natural soil characteristics in the subwatershed. It is important to monitor conductivity to determine if there are any potential water quality problems within a tributary subwatershed. Table 4-7 lists the mean tributary conductivity values for Partridge Lake.

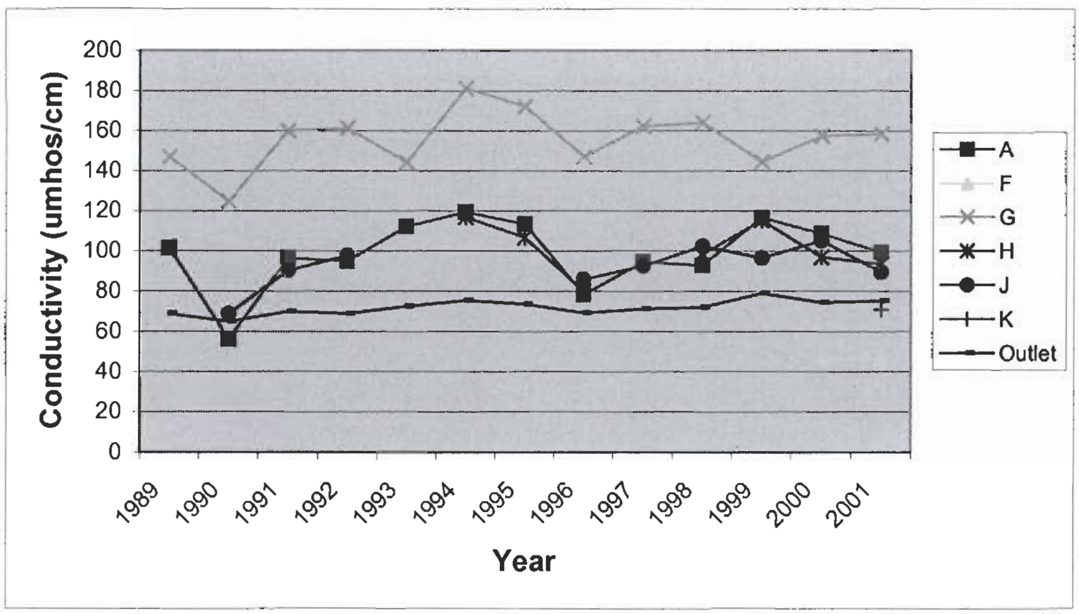
Table 4-7
Partridge Lake Tributary Mean Conductivity (µmhos/cm)

Tributary	Mean	Median	Standard Deviation
A	114.74	116.10	9.87
B	119.10	112.10	12.39
D	65.97	66.84	14.69
E	99.67	99.67	0.00
F	48.13	49.22	2.75
G	157.91	161.00	7.49
H	105.66	108.80	14.36
J	102.26	102.26	15.76
K	56.13	55.60	13.59
L	61.30	64.10	14.69
Outlet	77.30	77.58	1.76

Conductivity values between the Partridge Lake subwatershed tributaries are variable. The lowest mean conductivity was recorded at Tributary F, a seasonal stream derived from small seeps on the forested eastern shoreline of the lake. Ironically, tributary G, which is located just south of Tributary F, had the highest mean conductivity values throughout the study period. This is likely due to the fact that this stream originates higher up in the watershed, just below a large field that is used for dairy cow grazing. To generalize, tributaries with agricultural land uses in the headwaters (Tributaries A, G, H, and J) have slightly elevated conductivity levels.

Figure 4-9 shows the historic conductivity data.

Figure 4-9
Historical Trends in Tributary Conductivity (VLAP Data)



In summation, tributary conductivity values are not excessive for that area of the state and have remained relatively constant over the last 13 years.

4.2.3 Turbidity

As streams enter the lake, heavier sediment particles will settle out closer to the mouth of the stream. This will eventually build up over time and cause shifts in the stream channel as it enters the lake, possibly altering flow. Lighter sediment particles will travel farther into the lake with the flow of the stream, and may settle and accrete in slightly deeper waters. Table 4-8 summarizes the mean turbidity levels for the Partridge Lake tributaries.

Table 4-8
Partridge Lake Mean Tributary Turbidity (NTU)

Tributary	Mean	Median	Standard Deviation
A	0.14	0.10	0.07
B	0.40	0.42	0.05
D	0.24	0.24	0.10
E	0.20	0.20	0.00
F	0.21	0.20	0.14
G	0.19	0.13	0.16
H	0.23	0.21	0.14
J	0.22	0.22	0.00
K	0.26	0.17	0.23
L	1.03	1.02	0.78
Outlet	0.50	0.50	0.16

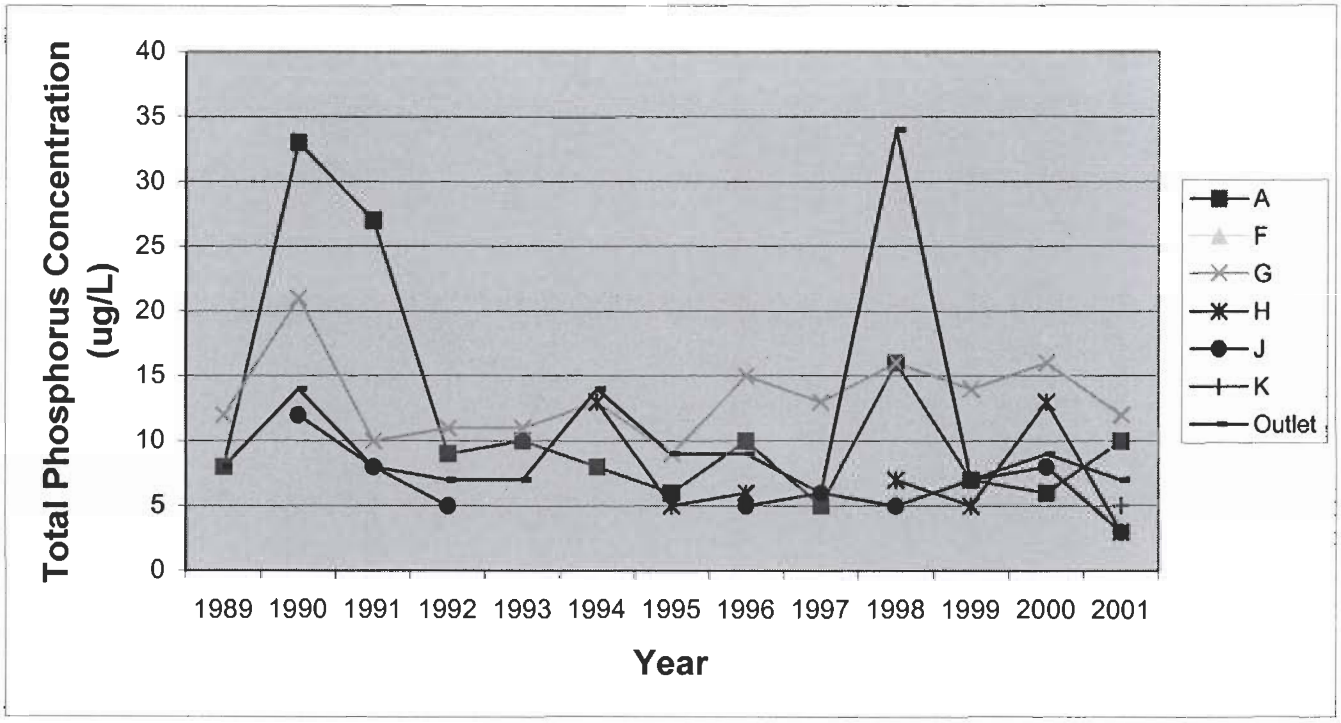
Tributary L had the highest mean turbidity during the study period. The elevated mean turbidity in Tributary L is likely due to wetlands located along this tributary. Loose flocculant organic material was often present in the stream flow.

For the most part there does not appear to be an excess amount of sediment entering the lake, as evidenced by the generally low turbidity levels. Observations of substrates at the mouth of the tributaries do not indicate areas of significant deposition.

4.2.4 Total Phosphorus

Phosphorus data for the tributaries show an occasional high concentration, but for the most part phosphorus remained around the mean for New Hampshire lakes. These spikes may be attributed to external loading from the watershed (human activities). Figure 4-10 shows trends in tributary total phosphorus concentrations since the lake joined the VLAP program. Phosphorus in the tributaries to Partridge Lake was discussed in more detail in chapter 3.

Figure 4-10
Historical Phosphorus Results for Partridge Lake Tributaries



5.0 WATERSHED MANAGEMENT AND LAKE PROTECTION

5.1 Introduction

From a review of the data collected during the diagnostic study of Partridge Lake and its surrounding watershed, NHDES has documented that certain activities around the watershed may be contributing to the decrease in water quality over time. *It is important to note that the lake is classified as borderline between advanced mesotrophic and early eutrophic conditions.* This indicates that the lake is clearly showing signs of impacts, and that lake aging may be accelerated because of those impacts.

The following observations and recommendations have been formulated to help maintain the current lake trophic status through slowing the aging process and, perhaps, to increase the water quality over time through conscientious watershed management.

In any lake protection or rehabilitation project, it is important to address the watershed factors that impact water quality first. Each source of pollution from the watershed must be addressed by providing appropriate Best Management Practices (BMPs) that decrease or eliminate the pollutant source before it enters the lake. No in-lake restoration or rehabilitation technique can be implemented until all the watershed sources have been managed. Any in-lake restorative work provided before watershed management is not cost-effective as the pollutant sources will soon create a reoccurrence of similar in-lake problems.

For each of the following sections in this chapter, a review of the general ecological and biological impacts will be made, followed by recommendations and related rules and statutes (if applicable). A summary of the areas of concern (ranked in order of priority for management) around Partridge Lake can be found in Table 5-1.

Table 5-1
Summary of Areas of Concern and Recommendations for Remediation

Problem	Recommendations	Suggested Timeframe	Cost
Stormwater Management	Install problem-specific Best Management Practices (BMPs) for each area of erosion around the lake edge	Fall 2005 through Fall 2006	Varies based on project
Septic Systems	For systems that are in failure or approaching failure, upgrade individual systems or identify locations where community septic systems may be an	Fall 2005 through Fall 2007	Roughly $5,000 to $30,000 per system for

	alternative		individual upgrades
Land Clearing and Development	Develop a zoning overlay for a Lake Protection Zone through the town of Littleton to protect areas that are not suitable for development based on soils, proximity to the lake, or other factors. If development is done, enforce the use of protective devices including silt fences, hay bales, check dams, and appropriate setbacks.	Winter 2005-2007 through completion	No to minimal cost if conducted by volunteers and town officials
Beach Erosion	Re-vamp beaches so that they are perched or so that slopes are minimized to lessen the impacts of overland runoff and subsequent erosion	Summer/Fall 2005	Case specific
Internal Loading	Once all watershed contributions of nutrients, sediments, and ions are minimized to the greatest degree possible, conduct an alum treatment to effectively trap the sediment phosphorus in the lake to prevent internal loading from occurring.	To be conducted once all watershed sources have been addressed.	\$70,000-\$80,000 for all costs associated with treatment

5.2 Stormwater Management

Since the largest source of phosphorus to Partridge Lake is from direct runoff, appropriate stormwater management practices in the watershed should be implemented. Development of residential areas around lakes and ponds has two main effects on stormwater. The first is the increase in the volume and rate of runoff as development occurs in a watershed. The second effect is the significant increase in phosphorus loading, which can result in the degradation of not only the surface water but the groundwater as well (RCCD, 1992). In addition to promoting erosion and sedimentation, increased runoff acts as a medium for transporting pollutants, which can contaminate surface waters and contribute to cultural eutrophication (human induced and accelerated eutrophication).

When development occurs, vegetation is removed and replaced with impervious surfaces. These surfaces include roads, streets, parking lots, rooftops, driveways, walkways, etc., which reduce the surface area for runoff filtration into the soil. The result is more untreated runoff entering directly into Partridge Lake. Natural drainage patterns are also modified as a result of development, and runoff is transported via road ditches, drainage swales and constructed channels. This can be seen by the long expanses of dirt channels along Partridge Lake Road.

These modifications concentrate and increase the velocity of the runoff, which in effect decreases the time for runoff to travel through the watershed. The increase in flow and decreased travel time of runoff has adverse impacts on the natural stream channel. The increased runoff volumes caused by residential development cause flooding to occur more frequently which causes the stream channel to widen and deepen to accommodate the increased flows. This natural process of stream channel erosion creates a sediment problem downstream. Erosional sediment deposits destroy habitats for vegetation and wildlife, impair aesthetic qualities, clog road culverts, degrade water quality, and accelerate lake filling, each of which has been observed, to some degree, in Partridge Lake.

Following is a discussion of identified areas of concern in the Partridge Lake watershed.

Site Specific Management of Non-Point Sources

Problem Area One: Partridge Lake Road Runoff and Shoreline Erosion

Location	Problem	Recommended Management
Old Partridge Lake Road	This is a steeply sloping hill with a tar road that wraps around down to the shoreline of the lake. Snowmelt and runoff travel down this hill, cross Partridge Lake Road, and erode sandy shoreline sediments adjacent to the lake and Tributary A (see Figures 5-1 and 5-2)	1. Hire a consultant to review runoff rates to determine feasibility of the following management techniques: a. On-site stormwater management to reduce runoff (rain gardens, infiltration areas, rain barrels, etc) b. Directed runoff to turnouts or catch basin/pipe systems that are then fed into adjacent wooded areas appropriate for infiltration c. Better designed road ditches to infiltrate stormwater by reducing velocities. (keeping in mind that reducing velocities will likely increase volumes, so these systems should be designed by a qualified engineer)

Figure 5-1: Showing erosion across beach from road runoff

Figure 5-2: Close-up of beach erosion

Problem Area Two: Shoreline Bank Erosion

Location	Problem	Recommended Management
Steep slopes along the lake edge	South Shore Road- there are points along this road where erosion is taking place due to the proximity of the road to the lake, and the steep shoulders of the road (see Figure 5-4)	1. Consider various low-impact, low-cost berms and/or plantings to reduce velocities and encourage infiltration is necessary. 2. If runoff is severe, engineered systems with infiltration catch basins may be beneficial.

Figure 5-3: Shoreline Bank Erosion

Figure 5-3 shows bank erosion occurring along a South Shore Road. During each rain event or melt event water runs over this steep bank, leading to erosion of the soil and slumping of the shoreline and rocks into the lake.

Problem Area Three: Dirt Drainage Ditches and Increased Turbidity in Lake

Location	Problem	Recommended Management
Dirt drainage ditches along Partridge Lake Road	Dirt drainage ditches exist along most of the shoreline roads. Some of these have culvert connections to the lake, sending turbid water into the shallows.	1. Plan and implement timely road sand clean-up practices in the spring following heavy sand applications during the winter season. 2. Investigate bank stabilization either by decreasing slope or adding rip-rap with filter fabric. 3. If bank stabilization is not feasible, consider catch basin systems with a strict maintenance schedule. A more costly yet effective fix is a Vortechnics type system to remove sediment particles. For all, maintenance is critical to success of the program.

Stormwater management within the Partridge Lake watershed should focus on developing, implementing, and maintaining appropriate BMPs on a site-specific basis for individual sub-watersheds. NHDES, local conservation districts and the Natural Resources Conservation Service (NRCS) can assist in choosing site specific BMPs. Appropriate permits or certifications may be necessary from the New Hampshire Wetlands Bureau, Shoreland Protection Program, and Subsurface Bureau, in addition to any local permits.

Between direct channelized flow and direct runoff, overland flow contributes an estimated 51% of the nutrients to the lake from the watershed. Storm water is an important focus for reducing nutrient inputs to the lake. Dirt roads in the watershed should be inspected, and their shoulders stabilized to prevent runoff from occurring. Riprapping the extensive drainage ditches and vegetating settling basins along these dirt roads would do much to lessen sediment transport. Appendix 6 details various aspects of BMPs.

5.3 Septic Systems

All of the homes around Partridge Lake are on subsurface systems or holding tanks. It is very important that residents know the location and age of their systems, and be aware of the need to have them regularly pumped and examined by a specialist. Data from this diagnostic study show that nearshore groundwater seepage contributes the second largest mass of phosphorus to Partridge Lake. The volume contributed from this source is second to runoff contributions, suggesting that septic systems have a large influence on the amount of phosphorus entering the lake.

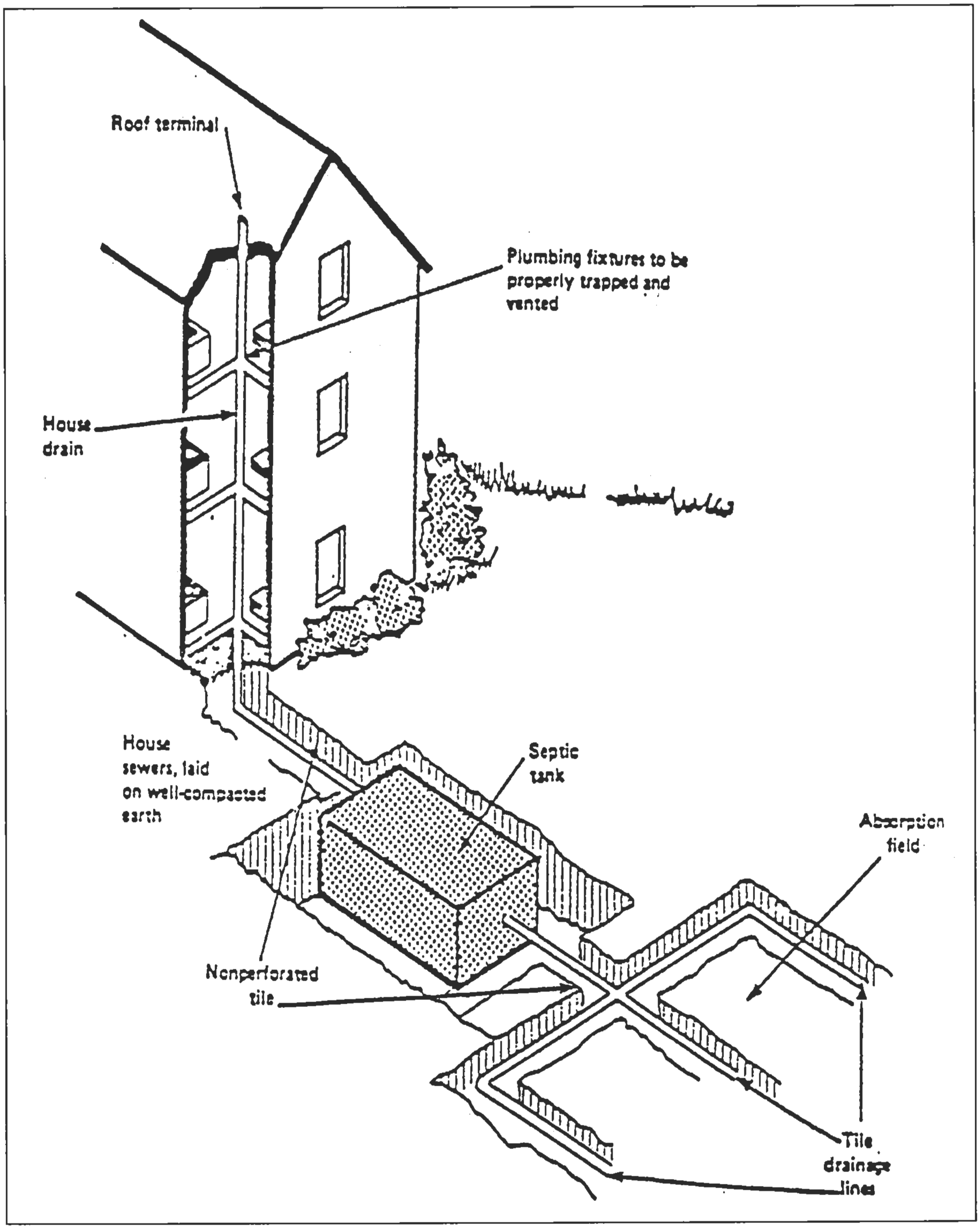
Further, from the septic system surveys conducted around Partridge Lake, it was determined that 36% of the septic systems have reached or exceeded their designed life span. Other studies conducted on New Hampshire lakes (Connor et al., 1992, and Connor and Bowser, 1997) concluded that much of the phosphorus from septic systems reaches the groundwater, and from there is transmitted to the shallow areas of the lake. The soil survey for the area indicates that there are limitations for septic system use based on shallow depth to bedrock in many areas of the watershed, and also due to highly permeable sandy soils throughout the watershed.

The most common type of individual disposal system is the septic tank – leachfield system as shown in Figure 5-1. The septic tank functions to separate the solids, both floating and settleable, from the liquid material. The accumulated sludge should be pumped out every three to five years (annually for shorefront residents). The liquid is discharged from the tank through piping material and distributed over the leaching area, which is designed to absorb the effluent and to remove impurities before it percolates to the groundwater.

In 1967, the New Hampshire legislature enacted a law to protect water supplies from pollution by subsurface disposal systems, and directed the Water Supply and Pollution Control Commission to establish minimum, statewide requirements for properly designed systems. However, this law provided no control over existing systems. The suggestions most pertinent to the prevention of surface water contamination by phosphorus are:

- Location of the system with respect to the surface water body,
- Soil permeability: the rate of water transmission through saturated soil, of which estimated soil retention coefficients varied with different lake sections,
- Land slope: steep slopes may cause erosion problems when associated with soils of low permeability. This is the result of overland flow of water due to the lack of absorptive

Figure 5-4
Diagram of Septic System Layout



- qualities of the soil.
- System age: soils have only a finite capacity for phosphorus absorption,
- Per capita occupancy: household population based on sanitary survey,
- Fraction of year system is in use (e.g., summer cottages or year-round dwellings), and
- Additional water utilizing machinery (e.g., washing machines, dishwashers, or garbage disposals). Systems should be specially sized if additional machinery is used on the premises.

When septic systems fail, they present a potential health hazard associated with the presence of untreated human wastes above ground and in surface waters. Groundwater contamination and subsequent pollution of drinking water is probable in many areas. Many systems will leach phosphorus into the groundwater and lake, accelerating the eutrophication process in Partridge Lake. The upgrading of old or failing septic systems could occur through four channels:

- Voluntary replacement;
- Proven failure and a subsequent order to replace the system from the health officer or the DES Subsurface Bureau;
- Conversion from seasonal to year-round use or addition of bedrooms; or
- Engineering study conducted prior to the house sale showing evidence that the septic system was in need of repairs or replacement.

5.3.1. Wastewater Treatment Considerations and Alternatives

a. Regional Waste Treatment. There is currently no sewage system used by shoreline residents, and no access to any nearby system that may be in place.

b. Cluster Systems. Cluster systems are innovative systems that collect and treat sewage for many homes or groups of homes around a lake. First tier development around Partridge Lake could elect the alternative of a subsurface treatment system with conventional collection from clusters or groups of individual homes. These cluster systems are usually simple and cost effective alternatives for the secondary treatment of small flows. Installations are suitable for discharge volumes of 500 gpd to 300,000 gpd. Small areas of land (perhaps shared lots or open lots) are necessary for the installation of such systems.

Cluster systems are becoming more popular as alternative systems, and there are several cluster systems that are now operational in New England.

Although a user fee would be required of all involved homes around the lake, the environmental and economic benefits could greatly outweigh the option of individual subsurface system upgrades that can become costly depending on lot size, configuration, and other variables.

c. Upgrading of Individual Systems. A wide range of individual treatment systems has been explored in the last few years due to a renewed interest in on-site disposal systems. The Federal Environmental Protection Agency has a thorough review system in their draft report "Innovative and Alternative Technology Assessment Manual." The fact sheets from that manual give a good outline of available alternatives. Other guidance documents can be found online at http://www.epa.gov/OWM/secttre.htm.

Individual treatment systems installed in recent years normally consist of a septic tank for solids separation and degradation, and a soil absorption system or leachfield to aid liquid percolation into the soil. The size of the tank is proportional to the expected usage, and the leaching field is sized according to both usage and soil characteristics. When soils are poor (i.e., low permeability) or flows are high, the leaching field must be large. Problems arise when the required design of the field is impractical or impossible due to lot restrictions and/or soil and groundwater conditions.

d. Compost Toilets. A reduction in wastewater volume entering the leaching field is possible by the use of a waterless toilet of the composting type. Wastewater is the by-product of all water used within the home including toilet facilities, cleaning, cooking and personal hygiene. The wastewater associated with toilet and urinal usage is considered concentrated human waste and classified as black water. Gray water comprises the remainder of the domestic wastewater such as water from baths, showers, sinks and washing machines. An approximately 40% reduction in total flow can be achieved by eliminating black water.

Compost toilets decompose human wastes by a natural biological process. With the aid of air and/or some heat, human waste will degrade itself over an extended period of time. This process is similar to the decomposition process in composting leaves and manure piles used for garden and agricultural crop enrichment.

A compost system utilizes a large compost chamber that must be installed in the basement or underground, and is called an external unit. The larger external units rely completely on natural processes. They have no external heat addition or composting aids as in the smaller internal units, where the addition of heat and compost aids (such as a starter bed or enzymes) speeds the degradation process, thereby decreasing the required volume. Toilet wastes enter through a toilet chute and accumulate in the compost chamber. Here, with air supplied through ventilation, warm temperatures and humidity, the waste begins to decompose. The process should create no odor since released gases and water are removed by outside ventilation and evaporation. Organic material such as food wastes should be introduced into the chamber to aid in the composting process.

The total decomposition time ranges from 1-1/2 to 2 years initially, and from 3 to 12 months thereafter. At the end of this time, the wastes have been reduced to rich, odorless humus that can be removed and used as garden soil. This is the only required maintenance except for the occasional addition of enzymes for certain internal units. For the internal units, electricity is required for heating and a ventilation fan, while some external units utilize convection currents for ventilation. The amount of humus produced varies with the system and ranges from 15 to 60 pounds per year per person.

e. Low Water Flush Toilets. Several low water flush toilets are available which utilize from one quart to two gallons of water instead of the average five to eight gallons used by a standard flush toilet. A limited capacity self-contained tank controls the volume of flushing water. Air in the tank is compressed as it is filled with water. When flushed, the compressed air forces the water through the toilet bowl at a faster rate, thereby requiring a lower volume to empty the bowl.

f. Gray Water Flow Reduction. Unlike concentrated human waste, gray water cannot be completely eliminated as domestic wastewater by recycling or composting. However, many devices are available for water conservation that greatly reduce gray water quantities. Flow restrictors and regulators can be placed on faucets and showerheads. The average person showering will use 6 gallons of water per minute for 7.5 minutes with a standard showerhead. Should a 3-gallon per minute flow reduction be installed, an average family of four persons could save 90 gallons of water per day, assuming each took one shower per day. Many of these flow reduction devices cost less than $15.00, and can be purchased at local hardware stores.

Water conservation and wastewater treatment methods described above may result in significant flow reduction to the ultimate treatment and disposal system. Assuming the average family produced 75 gallons per day per person, an estimated flow for their household is about 300 gallons/day.

5.3.2 Wastewater Treatment Alternatives Summary

A variety of alternatives are possible for the upgrading of individual treatment systems. Each alternative has limitations for proper operation including difficult climate, terrain, soils and/or groundwater conditions, personal acceptance, technical and administrative problems.

5.3.3 Septage Handling Alternatives

The cluster system alternative includes large septic tanks that require pumping every other year. One septage-handling alternative would involve pumping of the septage by a tank truck, owned and operated by a management district for Partridge Lake or the Town Littleton, or contracting with a private contractor to service shoreline sections of the lake on the same day. In either case, septage would be hauled to the nearest approved disposal site or wastewater treatment plant for further treatment. Wastewater treatment plants vary in their fees for septage disposal. It is cheaper and timelier to hire a contractor to suction a series of systems (such as a street or neighborhood) on a one to two day period than it is to schedule individual and random cleanings.

5.4 Land-clearing, Development, and Shoreland Protection

As the population continues to increase in New Hampshire and surrounding states, the acceleration of development in our watersheds is inevitable. Ultimately, more people will be drawn to the beauty of New Hampshire's lakes and ponds, and thus, development in nearshore watershed areas must be well-planned to prevent further degradation of our precious waterbodies. Poorly planned development can lead to problems with sedimentation, nutrient loading, algal blooms, decreased lake clarity, and declining property values. In the Partridge Lake watershed, new homes were recently developed within the 250 foot Protected Shoreland area. Since the field study terminated, the town, as well as the lake association, have been approached with proposals for developing larger tracts of land within the watershed of Partridge Lake. Careful consideration should be used when planning for and permitting future development. This section is intended to guide the town and the watershed residents in making wise and informed decisions on how to conserve and develop in the area of Partridge Lake, and implement Low Impact Development (LID) concepts in future development.

5.4.1 Minimizing the Impact of Future Development

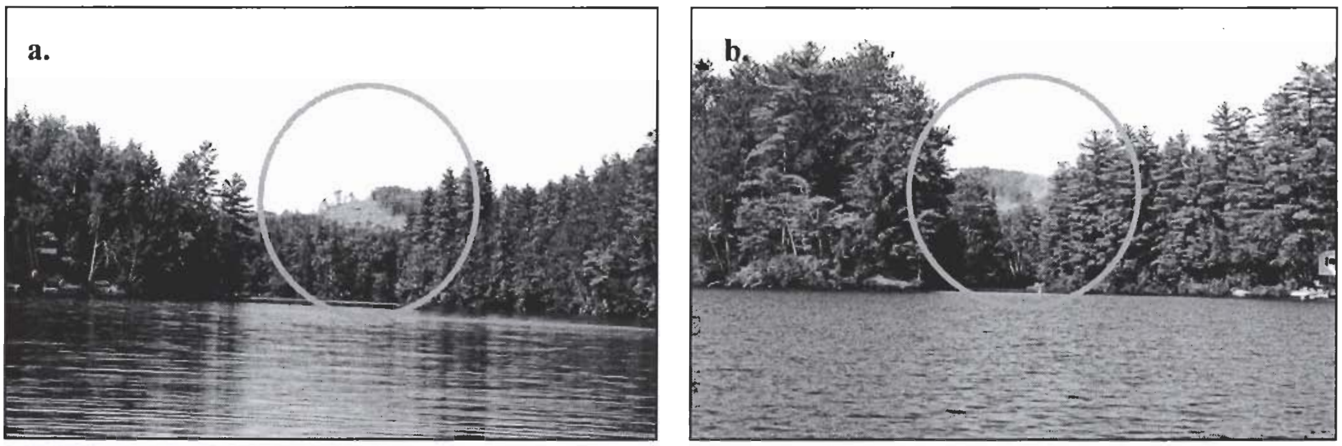
The location of development within the watershed and the design of individual developments and subdivisions will determine the effect of future development on Partridge Lake. Local zoning and land use regulations should be revised to prevent sprawling development from occurring throughout the watershed and encourage (or require) more environmentally-friendly site design, including improved on-site stormwater management, for new development.

Sprawling development across a watershed increases run-off pollution and poses a significant threat to the continued health of a waterbody. Low-density, large-lot development results in more clearing and land disturbance and generates more impervious cover per household and per person than clustering and village development. Local zoning and land use regulations should encourage new development within or close to existing developed areas and allow for clustering and higher-density, mixed-use village type development in areas where the impacts to natural resources and the community will be minimized. Local zoning should restrict development near surface waters and sensitive resources, especially small streams and wetland systems.

In addition, new developments should be encouraged (or required) to implement the practices of conservation design, which reduce impervious cover, protect sensitive resources, and better maintain the natural hydrology of the landscape. Conservation design not only reduces potential impacts on water resources, but also ensures that the new development is consistent with the broader environmental and social goals of the community. These principles can be applied when developing a land use plan for a community or watershed, to subdivision plans, and to individual residential, commercial and industrial sites. Appendix 7 provides slides from a presentation on minimizing the impact of development on water resources that present some specific areas where conservation design concepts can be applied. Appendix 8 has fact sheets and other general guidance on Low Impact Development.

Also, it is important to remember that development does not need to be in close proximity to the lake edge to directly impact the lake. Activities in areas are not distant to the lake, but which do not occur in the watershed of the lake can be problematic. Figure 5-5 (a) shows an example of a timber harvest near Partridge Lake that could have direct bearing on the water quality of the pond even though it is just outside of the physical watershed boundary. Airborn sediment particles shown in Figure 5-5 (b) are blown from exposed soils and can easily land on Partridge Lake or be brought down to the watershed through a precipitation event. Sediment particles have other chemically bound elements like phosphorus, attached to them.

Figure 5-5: Clear-cutting and Wind Erosion



5.4.2 Shoreland Protection

The theme throughout this study has been that activities taking place within the watershed affect the quality of the lake and other downstream surface waters. Evaluating this theory on a closer level, it should be evident that activities that take place directly adjacent to the lake acutely affect water quality (for both overland flow and tributary flow). The Comprehensive Shoreland Protection Act (CSPA) establishes guidelines for activities taking place within 250 feet of the high water line of the lake (or the elevation of the top of the dam), commonly called "the protected shoreland." The activities addressed within these rules include building, development, and forestry activities, to name a few. A complete copy of "The Protected Shoreland" guide to the Comprehensive Shoreland Protection Act can be found online at *www.des.state.nh.us*, or can be purchased through the NHDES Public Information Center at 603-271-2975. General fact sheets and a list of native plantings recommended by the Shoreland Protection Act can be found in Appendix 9.

It has been shown that maintaining or establishing a well-vegetated buffer along a water body can minimize erosion and nutrient inputs from the land surrounding the lake. In addition, establishing building and accessory structure setbacks allows for a buffer of natural land surrounding the lake for infiltration and uptake of nutrients prior to their entering the lake. Since a lot of the shoreline area is already developed, maintaining the trees that are still standing is now critical.

In addition to establishing setbacks, the CSPA provides lists of native plants, shrubs, and trees that could be used to revegetate shorefront properties. Residents of shoreline areas should be encouraged to maintain a healthy, well-distributed stand of trees, shrubs, and groundcovers. These plants not only serve to take up nutrients and stabilize soils, but they also provide privacy and shade.

Shoreline residents of Partridge Lake should be aware of the provisions in the Comprehensive Shoreland Protection Act.

5.4.3 Zoning

Impacts from development can be reduced through the establishment of appropriate zoning ordinances

The purpose of a zoning ordinance is to regulate the use of land in a manner that promotes the health and welfare of a municipality. It includes requirements to lessen congestion in the streets, secure safety from fires, panic and other dangers, and to prevent detrimental environmental impacts from development. Ordinances are primarily designed to provide adequate infrastructure to meet municipal needs for such services as transportation, solid waste facilities, water, sewerage, schools and parks. Zoning ordinances can also be used to provide greater protection of important natural resources.

Some towns have established ordinances that pertain directly to surface water protection. These may include ordinances to protect special or unique natural resources throughout the community, like a wetlands ordinance, or identify a specific area warranting greater protection. The Town of Littleton has included a minimum septic system setback requirement of 125 feet from the shoreline of a waterbody in their town zoning ordinances, but the ordinances include few other measures to protect lakes and ponds. Therefore, Littleton may want to establish an environmental protection overlay or watershed district to provide greater protections for Partridge Lake. Grants may be available to aid towns in these activities.

Many cities and towns have chosen to use overlay zones or districts to protect valuable water resources. An overlay zoning district is a district that is applied on top of the existing district in a particular area. It can either add or remove restrictions in the underlying area; in the case of shoreland or surface water protection districts, it usually adds restrictions.

Overlay districts in other cities or towns could serve as a starting point for establishing such protection around Partridge Lake. For example, several New Hampshire towns have written shoreland protection districts into their zoning code. Sunapee, New Hampshire has designated all lands within 300' of lakes and ponds greater than 10 acres as part of its Shoreline Overlay District. Junkyards, waste facilities, and fertilizer are prohibited within the district. The town also requires erosion and sedimentation control plans for any construction within the district and has set a "natural woodland buffer" within 150' of shoreline where any cutting or clearing is subject to specific restrictions. Details of Sunapee's zoning code can be found at http://www.town.sunapee.nh.us/planzone/zoningregs.htm#art2.

The town of New London has a shoreland overlay district protecting 300' inland from its lakes and ponds. The zoning code specifies minimum setbacks from shore, requires erosion and sedimentation control plans for any construction, and sets limits on beach replenishment. Article XVI of New London's code describes its shoreland overlay regulations: http://www.nl-nh.com/03zoningord.pdf

Two other towns in NH have recently put a lot of effort into changing their zoning ordinances to protect their waterbodies. Appendix 10 has copies of the zoning ordinance overlays for the towns of Deering and Franklin, NH

Cities and towns in other states have also incorporated shoreland protection into their zoning code. The city of Big Lake, Minnesota has a shoreland management overlay district for the purpose of "providing for the wise utilization of shoreland areas in order to preserve the quality and natural character of these protected waters of the City," as stated in the city code. The city has outlined what development uses are permitted within the shoreland overlay district and what additional measures must be taken to protect the water body in question. Commercial planned unit developments are prohibited within the shoreland overlay district and any industrial or semi-public developments without water-oriented needs (such as boat rental businesses) must not be located directly on the waterfront. Agricultural use is permitted within the overlay district, but the city requires that any steep slopes or shore impact zones be maintained with permanent vegetation to prevent erosion and runoff. Any steeply sloped areas within the overlay district must be examined by the zoning administrator before being approved for any type of construction or development.

Additionally, there are restrictions on vegetative clearing in the overlay zone, and all roads and parking areas and any construction activities must be designed to limit erosion and runoff to waterbodies. Zoning requirements in the overlay district also subject proposed septic system sites to strict evaluation with an eye to possible water contamination. Details of the Big Lake shoreland management overlay district can be found in Chapter 10, section 1065 of the code of the City of Big Lake: http://www.biglakemn.org/city_code/2004%20Master%20Adobe%20Format/Chapter%2010%20Zoning/ZO%2065%20SHORELAND.pdf.

The city of Plymouth, Minnesota has a shoreland overlay district similar to that of Big Lake that also specifies lot size and minimum setback requirements for buildings, roads, and septic systems within the overlay district, as well as setting limits on the percentage of impermeable surface of each lot. To read Plymouth's regulations go to: http://www2.ci.plymouth.mn.us/pls/cop/docs/FOLDER/CITY_GOV/CG_ZONE/ZONING_TOC/21665-SHORELAND_MANAGEMENT_OVERLAY_DISTRICT.PDF.

While none of these examples are comprehensive, they may provide helpful suggestions for what types of protection can be included in shoreland overlay zoning. Town planning boards and lake associations should always refer to the Comprehensive Shoreland Protection Act to ensure that proposed zoning regulations comply with its requirements.

For additional guidance on implementing shoreland protection zoning, the Wisconsin Lakes Partnership has published a series of fact sheets pertaining to zoning ordinances and shoreland management. These can be found at http://www.uwsp.edu/cnr/uwexlakes/ FactSheetList.htm.

Recommendation

Maintaining permeable areas, forested and ground cover buffers, and keeping lawns and paved areas to a minimum are critical in maintaining the health of the lake. Zoning ordinances and overlay districts should be created or expanded in ways that are consistent with the provisions of the Shoreland Protection Act and with new and innovative Smart Growth and Low Impact Development planning. It is recommended that the Partridge Lake Association and the Town of Littleton designate a subcommittee to investigate options for developing town and watershed wide zoning overlays and districts that are consistent around the lake.

This subcommittee should use plans that are already established as guidelines when formulating appropriate zoning and overlay districts for the watershed area of Partridge Lake. Examples and references cited in this section are a good start for the committee.

5.5 Beach Erosion

Sand beaches are potentially damaging to the lake due to the filling in of shoreline habitat and the introduction of nutrients into the lake (phosphorus binds to sediment particles). There are a few beaches on Partridge Lake that are frequently replenished with fresh sand, and observable problems were noted with each. Figure 5-6 shows beach erosion occurring at a site on Partridge Lake. Shallow areas newly created by beach erosion allow for greater areas of sunlight penetration, and may also encourage even more abundant plant establishment along the shoreline areas of the lake.

Areas of the lakebed near eroding beaches often show signs of sedimentation. As new layers of sand cover shoreline habitat, macroinvertebrate communities, fish spawning areas, and amphibian habitat may be covered or destroyed.

Figure 5-6: Beach Erosion

Fresh sand is easy to identify on the lakebed, as it appears cleaner (less organic build-up) than surrounding bottom sediments.

By installing a permitted perched beach with a diversion trench along the upper limit of sand, overland runoff is diverted around a sloping beach, and rocks placed at the toe of the slope prevent direct washing of the sand to the lake. The NHDES Wetlands Bureau has guidelines for establishing perched beaches to reduce the likelihood of erosion and sedimentation (Appendix 11). The Wetlands Bureau not only requires permits for beach construction and replenishment, but also restricts the time interval between beach replenishments to once every 6 years.

5.6 In-Lake Management - Phosphorus Inactivation

Phosphorus precipitation and sediment inactivation through aluminum salts injection are lake restoration techniques that reduce phosphorus concentrations and thereby limit the growth of algae. Sediment phosphorus inactivation results in longer-term lake quality improvement when compared to water column precipitation. Sediment inactivation is particularly useful in accelerating lake improvement in those areas where internal phosphorus loading contributes a significant portion of the nutrient budget. It is also important to note that all watershed sources of phosphorus must be reduced or eliminated prior to the use of this technique. Watershed inputs that are high in nutrients would only counteract the goal of phosphorus control from within the lake.

Some of the benefits of aluminum salts injection include the reduction of in-lake phosphorus concentration and internal loading, increased transparency, and reductions in algal abundance.

Some potential drawbacks of this procedure deal with the chemistry of the compounds being added. In lakes with low buffering capacity (low ANC), small doses of aluminum sulfate can exhaust the buffering capacity to a point that causes lake pH to fall below 6.0. When this happens, aluminum may be released from the compound, causing aluminum toxicity to occur. There are methods to ameliorate this potential, which involve adding salts to buffer the acidity.

A local example of such a treatment is with Kezar Lake in North Sutton, New Hampshire. Aluminum sulfate and sodium aluminate were used as sediment phosphorus inactivants to improve lake quality. The treatment occurred during June of 1984. A four-year monitoring program provided an extensive lake database to evaluate the short-and-long-term effectiveness of sediment phosphorus inactivation as a lake restoration technique. An immediate impact of treatment was a reduction in the depletion of oxygen in the hypolimnion, resulting in the maintenance of oxygen in the hypolimnion, a decrease in algal abundance (measured by chlorophyll-a concentrations), improved transparency, and a shift from blue-green algal dominance to species of algae typical to lakes and ponds in New Hampshire. No negative impacts to lake organisms or lake chemistry were detected in the post-treatment monitoring program (Connor and Smagula, 2000). Now, nearly twenty years later, the lake is still showing signs of good water quality.

An Aluminum salts treatment for Partridge Lake would cost approximately $70,000-$80,000 (quoted in 2005).

5.7 Other Considerations

5.7.1 Aquatic Plant Management

As indicated in Chapter 4.0 of this report, aquatic plants are rated as "scattered/common." For the most part, aquatic vegetation can be found along the entire shoreline of the lake, with mixes of emergent, floating and submergent vegetation. Figure 5-7 shows a typical example of the aquatic plant community in Partridge Lake.

Yellow and white pond lilies and pondweeds are the most abundant plants in the lake. Pond lilies have extensive tuber systems in the sediments. Lake residents often pull up the lily pad and its petiole (stem), thinking that will eliminate the problem. In truth, removal of the full rooting system is necessary to minimize the problem (an activity which requires a permit).

Figure 5-7

Pondweeds reproduce by seed. Robbins pondweed (*Potamogeton robbinsii*) and bass weed (*Potamogeton amplifolius*) are the two most common pondweeds in the lake, and provide excellent fish habitat. Robbins pondweed has a tall feather-like structure with nearly opposite, long leaves and resembles a feather frond. Bass weed is the pondweed that has the long curlier leaves. For control, removal of the plants before they go to seed is important.

It should be remembered, however, that nutrients are constantly being supplied to the lake, and these nutrients are used by both plants and algae. Removal of large amounts of plants and their nutrient uptake functions may shift the plant dominance in the lake over to algae, causing decreased clarity and algae blooms. If plant removal is necessary, controlled removal of plants, on a schedule that allows a few years in between each management practice, is the best for the lake. Drastic changes in lake community components should be avoided. Remember that permits are needed by the Department of Agriculture for any chemical control of plants, and permits from the Wetlands Bureau are needed for any physical removal of plants in a lake or pond.

The lake association and lake residents should continue to be active in the volunteer Weed Watcher Program offered by NHDES. This program involves a once a month survey of the shallow areas of the lake for growths of any exotic plants, such as milfoil. The surveys should be conducted from late May through the end of September. There is no way to eradicate exotic plants once they find their way into a lake or pond, but it is easier to manage them if they are identified early, should they be introduced.

5.7.2 Public Education

The Partridge Lake Association should continue with their efforts aimed at educating lake and watershed residents and transient lake users. This education program should be expanded to encompass residents within the entire watershed, specifically targeting developed areas adjacent to surface waters. The ultimate goal of this type of program is to reduce the amount of nonpoint source pollution within the watershed and to eliminate the effects of cultural eutrophication upon Partridge Lake. Pollution prevention is much less costly than rehabilitation and remediation techniques.

Given a choice and a better understanding of the consequences of their actions, most people will opt to improve their environment. If all residents of the Partridge Lake watershed could enjoy the benefits of a choice recreational resource, they would likely take a greater interest in protecting water quality.

The lake association is a valuable and effective vehicle for conveying information to the residents and transient population of the Partridge Lake watershed. The existing infrastructure and long term goals of the Partridge Lake Association will coincide with the recommendations for public education outlined in this study and should include the following:

- Continuation of Partridge Lake Association sponsored activities revolving around public education as it pertains to shoreland protection, watershed management and lake ecology. Other lake associations have developed folders or binders of information which are distributed to lakeshore residents. These folders contain fact sheets, laws and regulations dealing with Subsurface Bureau Rules, Shoreland Protection Rules, Wetlands Bureau rules, and other pertinent information.
- Continued participation in an organized volunteer monitoring program and the Weed Watcher Program.
- The town of Littleton should encourage their elementary and secondary schools to participate in the NHDES Interactive Lake Ecology program. This program is designed to educate the young on principles of lake ecology and preservation of these resources, ensuring that the future residents of the area have the necessary education to safeguard

their water resources.

- Promote the use of new technology efficient marine engines
- Obtain grant money or other funds to purchase and distribute low flow showerheads to residents adjacent to the lake.
- Establish a shoreland vegetation program to promote a well-vegetated buffer of native plant species along shorelines. Perhaps the lake association can work with local garden centers to establish a list of native plants, and work on an annual plant sale for the Partridge Lake watershed.

Seasonal to year-round residence conversions on Partridge Lake, coupled with the increasing utilization of the lake, necessitate a comprehensive educational program within the Partridge Lake watershed. Implementation of the recommendations listed above will act to mitigate nonpoint source pollution around Partridge Lake and reduce the impacts of cultural eutrophication.

5.7.3 Future Monitoring

Because the study was conducted during a confined time frame, only a representative data set could be collected for that period in time. Water chemistry, physical conditions, and biology can vary between seasons, between weather events, with development, and with time.

To be sure that residents, biologists, and the community as a whole understand the activities taking place in both the watershed and the lake, it is important to continue monitoring the lake and watershed.

Recommendations for Monitoring

- Continue monitoring the lake each spring and summer with an organized volunteer lake monitoring program. Continuous data over a long period of time enable scientists to determine realistic trends in the watershed and the lake. These trends may be from year to year, or may occur over two, five, ten, or one hundred years. Partridge Lake has been monitored regularly for over 15 years, and this trend should be continued in the future.
- Encourage more lake residents to become volunteer Weed Watchers. Long-term records

of plant growth (both native and exotic) can be valuable tools in tracking the aging of a lake.

5. 8 Lake and Watershed Projects- Assistance and Funding

To implement some of the recommendations of this report, alternative funding sources will likely be required. One possible funding source for implementation and/or further watershed assessment is the NHDES Nonpoint Source (NPS) Local Initiative Grant Program. This NHDES administered program is the result of Clean Water Act, Section 319 (h) nonpoint source funding provided by the United States Environmental Protection Agency (USEPA).

The NPS Local Initiative Grant Program is available to municipalities, regional planning agencies, non-profit organizations and conservation districts, and can be used to address nonpoint source issues ranging from contaminated storm water runoff to streambank erosion to watershed planning. In order to apply for the grant program, you must submit a proposal that meets the requirements of the annual Request for Proposal, which historically has been issued in early September with a deadline of early November. While the requirements may change, presently applicants need to meet two key criteria:

1. <u>40% of the total project expense must be provided by the applicant</u>

This 40% soft match can include volunteer time, town employee time, donated materials, etc. For example, the lake association or town Conservation Commission could submit a NPS Local Initiative proposal for storm event monitoring to identify pollution sources. The proposal could be crafted so that 60% of the total funding amount could pay for sample analysis, and the remaining soft match could be the volunteer time (presently valued at $17.19/hr) used to collect the samples.

2. <u>Projects should indicate a clear path towards implementation</u>

This simply means the applicant has to outline the schedule for the project from start to finish. Using the above example, the applicant would provide estimated dates for recruiting and training of volunteers, when the sampling window would be*, and when the final report would be submitted to the DES. (**Note: Since the theoretical proposal would include a monitoring* *component, a Quality Assurance Project Plan would have to be submitted and approved by the USEPA prior to commencement of monitoring).*

The NPS Local Initiative Grant Program is the logical next step to help protect Partridge Lake. The Biology Section of NHDES has a staff person designated to assist lake associations and communities in the development and submittal of grant proposals, and assist with the implementation of grants that are awarded. Please contact the NPS Program Coordinator at 603-271-5334 if you are interested in pursuing water quality improvement funds through the NPS Local Initiative Grant Program. This report will be submitted to the NPS Program Coordinator for the development of possible 319 projects for 2005.

BIBLIOGRAPHY

Burns, N.M. 1970. Temperature, Oxygen and Nutrient Distribution Patterns in Lake Erie. J. Fish Res. Board Can. 33:485-511.

Carlson, R.E. 1977. Trophic State Index for Lakes. Limnol. Oceanogr. 22:361-369.

Connor, J.N. and M. Bowser. 1997. Flints Pond Diagnostic and Feasibility Study. Final Report. New Hampshire Dept. Envir. Serv. NHDES-WD-1997-1.

Connor, J.N. and S. Landry. 1995. Pawtuckaway Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Division. Staff Report No. 95-2. 690 pp.

Connor, J.N. and M.R. Martin 1988. French and Keyser Ponds Diagnostic and Feasibility Study. New Hampshire Dept. Envir. Serv. Staff Report No. 157. 395 pp.

Connor, J.N., P.M. McCarthy and M. O'Loan. 1992. Mendums Pond Diagnostic/Feasibility Study. Final Report. New Hampshire Dept. Envir. Serv. NHDES-WSPCD-92-4.

Connor, J.N. and M. O'Loan. 1992. Beaver Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Division. Staff Report No. 92-15. 690 pp.

Connor, J.N. and G.N. Smith. 1983. Kezar Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Commission. Staff Report No. 35. 690 pp.

Connor, J.N. and A.P. Smagula. 2000. A Study of the Effectiveness, Longevity, and Ecological Impacts of Hypolimnetic Aluminum Injection in Kezar Lake, North Sutton, New Hampshire. Final Report. New Hampshire Dept. of Env. Svcs. NHDES-WD-00-2.

Dillon, P.J. and F.H. Rigler. 1974. The Phosphorus - Chlorophyll Relationship in Lakes. Limnol.Oceangr. 18(5):767-773.

Edmondson, W.T., 1972. Nutrients and Phytoplankton in Lake Washington. P. 172-188. IN: G.E. Likens Nutrients and Eutrophication. Special Symposia Volume I. Amer. Soc. Limnol. Oceanogr.

Jones, R.A. and G.F. Lee. 1977. Septic Tank Disposal Systems as Phosphorus Sources for Surface Waters. EPA 600/3-77/129. 62 pp.

Knox, C.E. and T.J. Nordenson. 1955. Average Annual Runoff and Precipitation in the New England-New York Area. Hydrologic Invest. Atlas HA 7. U.S. Geol. Surv. 6pp.

Lakes Region Planning Commission. 1978. Lakes Region Water Quality Management Plan. Final Plan/EIS.

Lee, D.R. 1972. Septic Tank Nutrients in Groundwater Entering Lake Sallie, MN. Masters Thesis, Univ. Of North Dakota. 96 pp.

Likens, G.E., and F.H. Bormann. 1995. Biogeochemistry of a Forested Ecosystem. Springer-Verlag, New York. 2nd Edition.

Lorenzen, M. and A. Fast. 1977. A Guide to Aeration/Circulation Techniques for Lake Management. EPA-600/3-77-044. 126 pp.

New Hampshire Water Supply and Pollution Control Commission. 1975. Nutrient Removal Effectiveness of A Septic Tank-Leaching Field System. Staff Report No. 65. State of New Hampshire. 145 pp.

New Hampshire Department of Environmental Services. 1996. Informational Resources Management Unit.

New Hampshire Department of Environmental Services. 1996. Quality of New Hampshire Lakes and Ponds. A Layman's Guide.

New Hampshire Department of Environmental Services. 1993. Lake and Pond Inventory Report, Volume X.

New Hampshire Office of State Planning. 1991. Squam Lakes Watershed Plan.

Rockingham County Conservation District. 1992. Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire. Prepared for NHDES in cooperation with USDA and SCS. 422 pp.

Scalf, M.R., W.J. Dunlap and J.F. Kreissl. 1977. Environmental Effects of Septic Tank Systems. EPA-600/3-77-096. 34 pp.

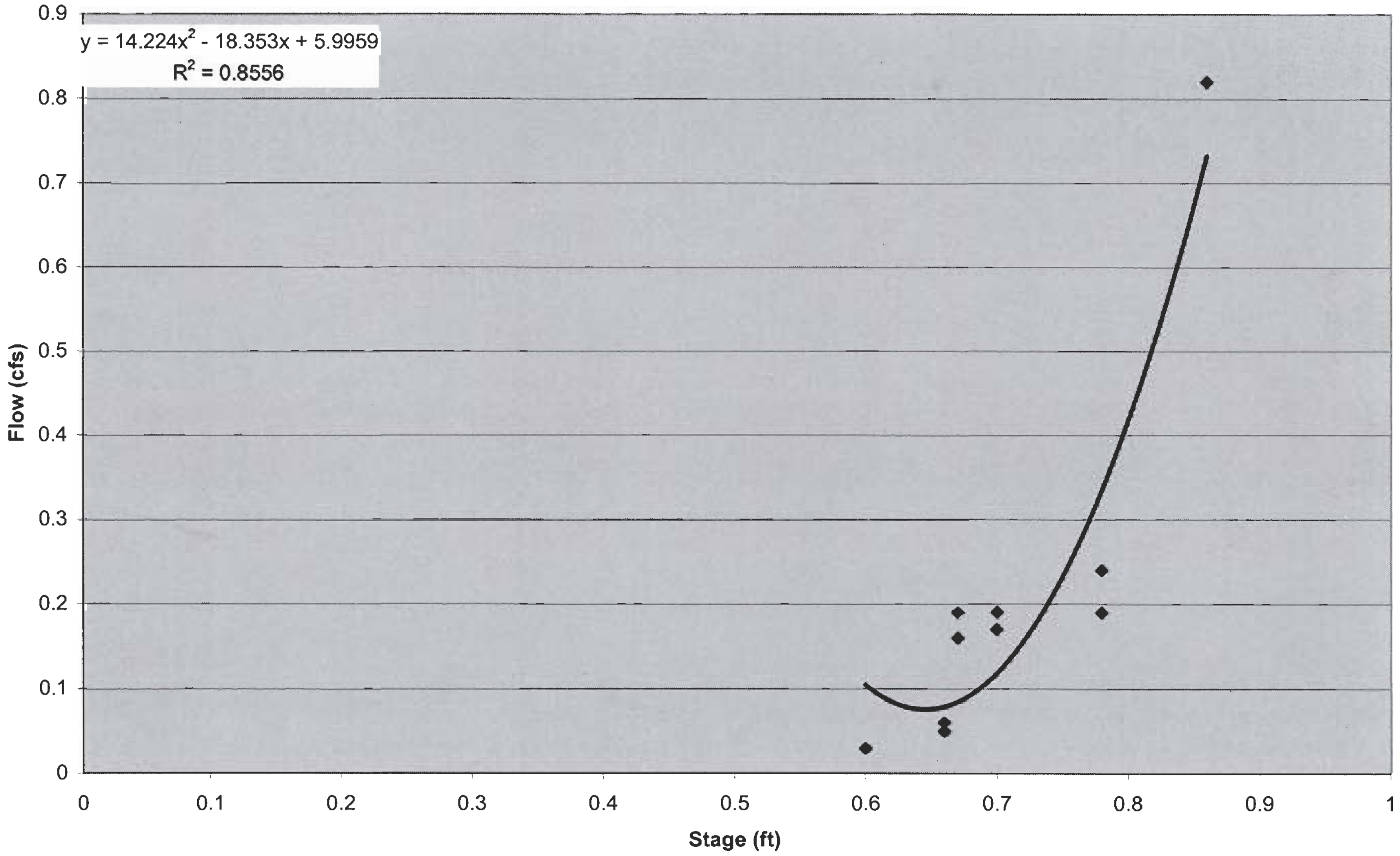
United States Environmental Protection Agency. 1980. Clean Lakes Program Guidance Manual. Washington, D.C. EPA-440/5-81-003. 148 pp.

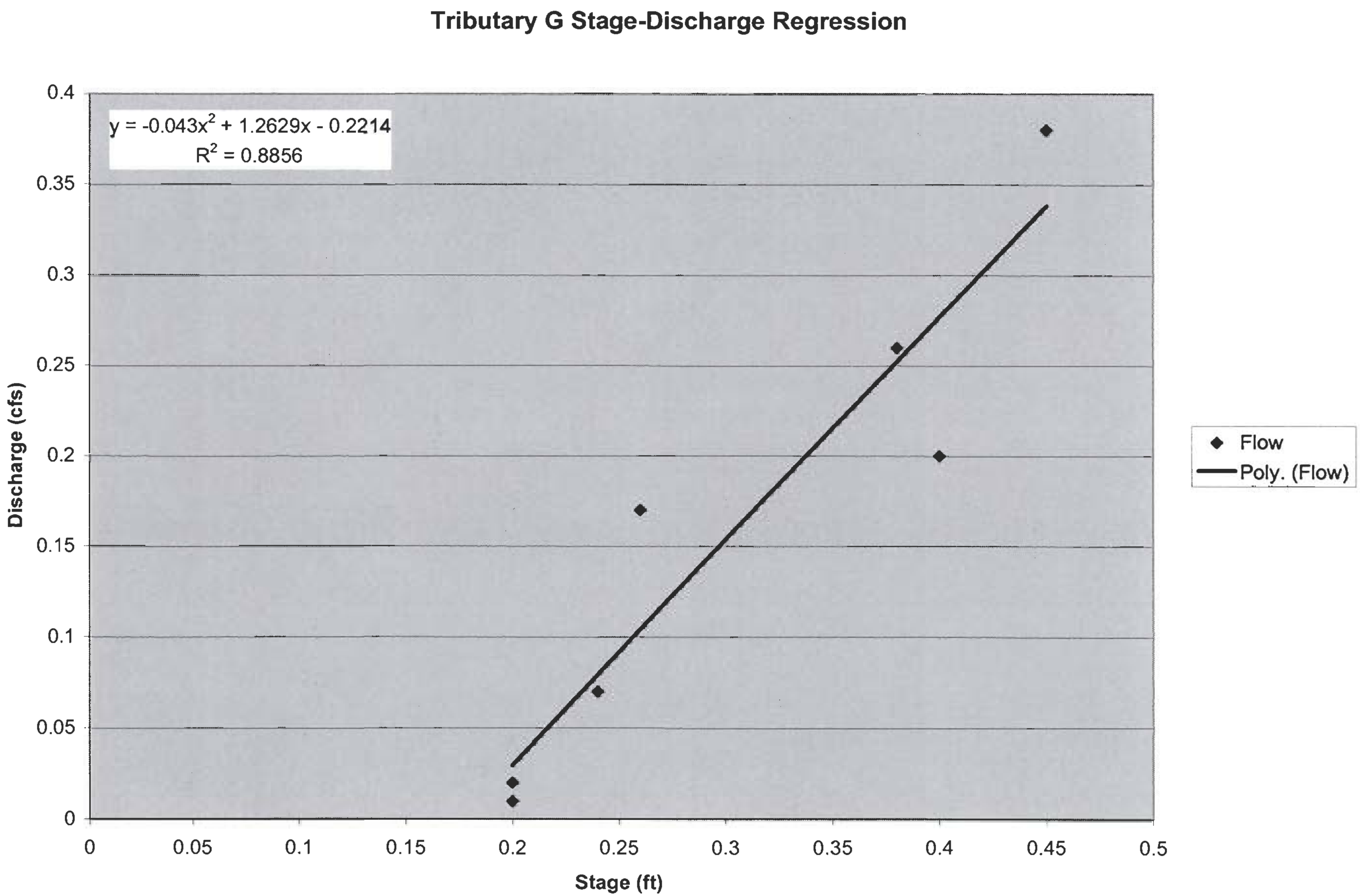
Vollenweider, R.A. 1975. Input-output Models, with Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrologic. 37:53-84.

Appendix One

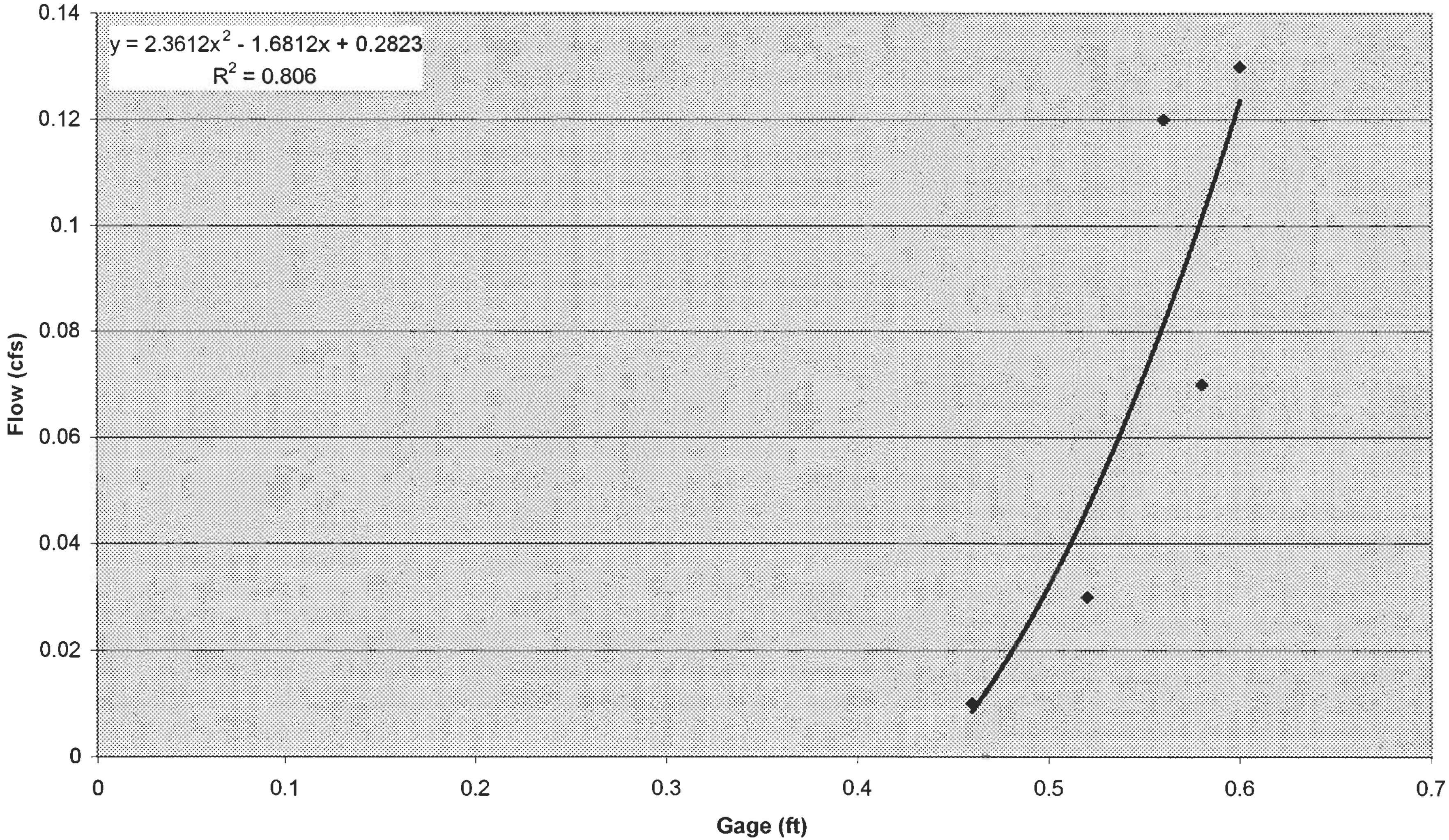
Hydrologic Budget Raw Data and Calculations

Partridge Lake- Tributary A

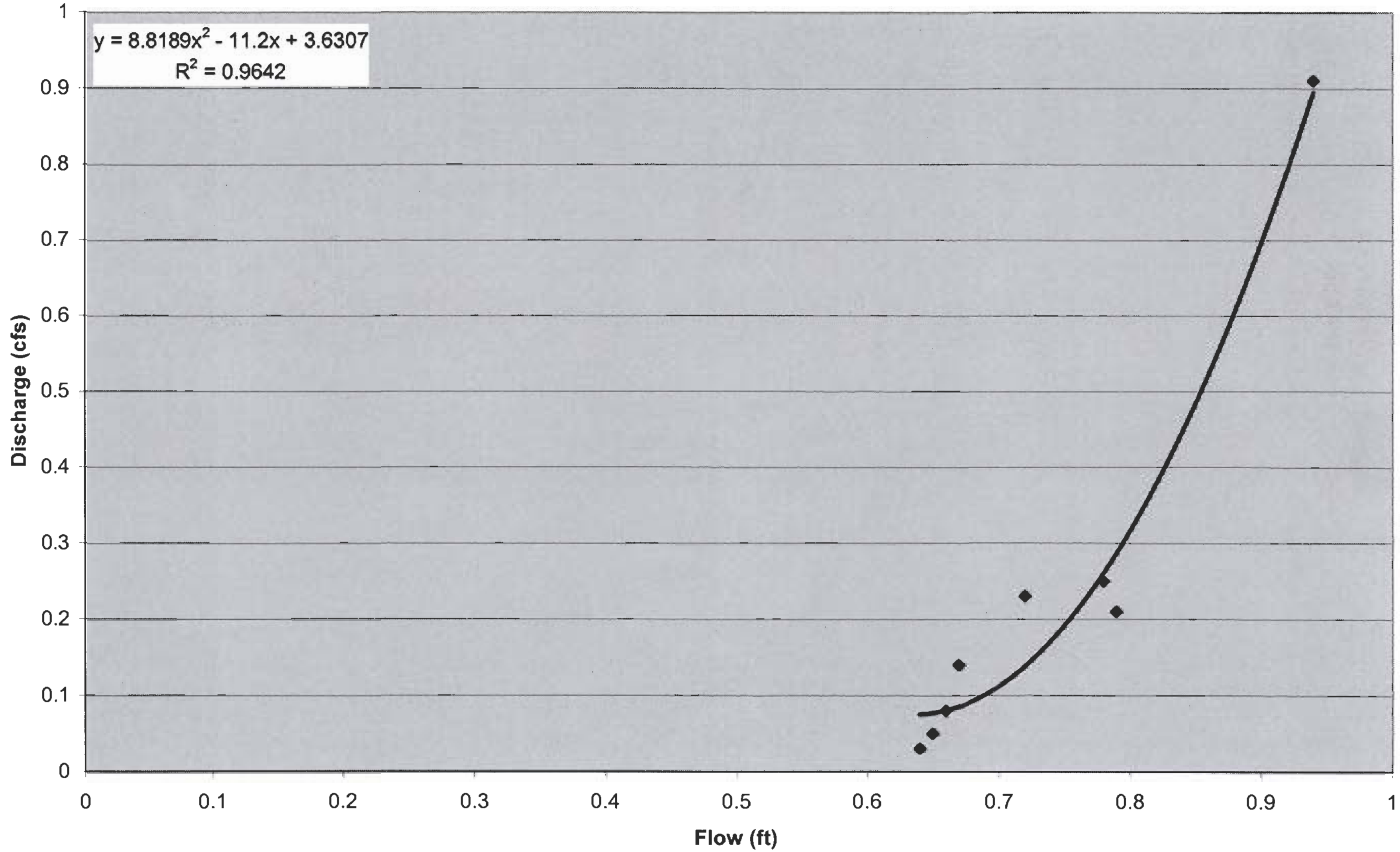


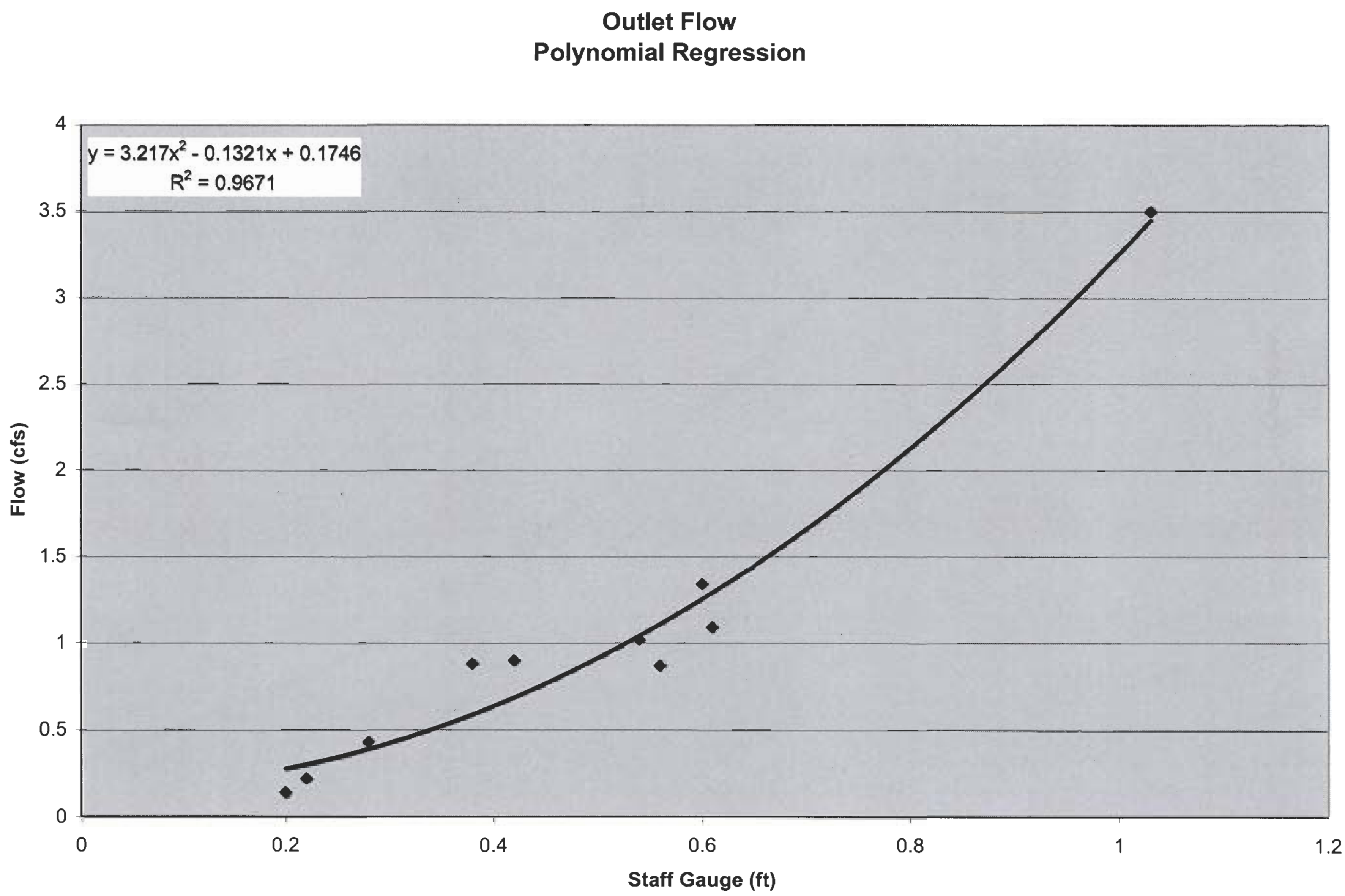

Tributary G Stage-Discharge Regression
y = -0.043x2 + 1.2629x - 0.2214
R2 = 0.8856
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Discharge (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Stage (ft)
Flow
Poly. (Flow)

Partridge Lake- Tributary H
Polynomial Regression



Tributary J Stage-Discharge Relationship




Outlet Flow
Polynomial Regression
y = 3.217x2 - 0.1321x + 0.1746
R2 = 0.9671
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
0
0.2
0.4
0.6
0.8
1
1.2
Staff Gauge (ft)

Raw Data Calculations for Year Round Tributaries							
Tributary	*Month*	*Flow (cfs)*	*Flow (m^3/s)*	*Flow (m^3/d)*	*Flow (m^3/mo)*	*10^3 m^3*	*Yearly Sum (103m3)*
A	June-00	0.14	0.00	336.10	10083.13	10.08	
A	July-00	0.03	0.00	83.91	2601.17	2.60	
A	August-00	0.11	0.00	256.62	7955.07	7.96	
A	September-00	0.15	0.00	354.25	10627.59	10.63	
A	October-00	0.27	0.01	643.72	19955.17	19.96	
A	November-00	0.26	0.01	639.97	19199.16	19.20	
A	December-00	0.15	0.00	367.78	11401.27	11.40	
A	January-01	0.15	0.00	367.78	11401.27	11.40	
A	February-01	0.16	0.00	390.26	10927.16	10.93	
A	March-01	0.11	0.00	266.11	8249.47	8.25	
A	April-01	0.46	0.01	1107.68	33230.52	33.23	
A	May-01	0.07	0.00	174.96	5423.70	5.42	151.05
G	June-00	0.17	0.00	411.26	12749.18	12.75	
G	July-00	0.13	0.00	314.50	9434.88	9.43	
G	August-00	0.02	0.00	48.38	1499.90	1.50	
G	September-00	0.03	0.00	60.83	1885.60	1.89	
G	October-00	0.04	0.00	104.49	3134.67	3.13	
G	November-00	0.03	0.00	67.23	2084.01	2.08	
G	December-00	0.09	0.00	217.51	6525.20	6.53	
G	January-01	0.10	0.00	246.88	7653.34	7.65	
G	February-01	0.07	0.00	180.08	5582.59	5.58	
G	March-01	0.13	0.00	311.35	8717.80	8.72	
G	April-01	0.58	0.02	1401.59	43449.27	43.45	
G	May-01	0.33	0.01	807.33	24219.89	24.22	126.94
H	June-00	0.08	0.00	181.93	5639.94	5.64	
H	July-00	0.08	0.00	188.13	5644.00	5.64	
H	August-00	0.02	0.00	50.80	1574.90	1.57	
H	September-00	0.03	0.00	62.32	1931.80	1.93	
H	October-00	0.08	0.00	200.03	6000.97	6.00	
H	November-00	0.06	0.00	146.24	4533.32	4.53	
H	December-00	0.00	0.00	0.00	0.00	0.00	
H	January-01	0.19	0.01	452.70	14033.63	14.03	
H	February-01	0.00	0.00	0.00	0.00	0.00	
H	March-01	0.00	0.00	0.00	0.00	0.00	
H	April-01	0.29	0.01	692.72	21474.38	21.47	
H	May-01	0.01	0.00	15.10	452.91	0.45	61.29
J	June-00	0.12	0.00	284.93	8832.91	8.83	
J	July-00	0.08	0.00	198.74	5962.09	5.96	
J	August-00	0.05	0.00	122.63	3801.43	3.80	
J	September-00	0.00	0.00	0.00	0.00	0.00	
J	October-00	0.11	0.00	267.72	8031.67	8.03	
J	November-00	0.16	0.00	379.10	11752.22	11.75	
J	December-00	0.21	0.01	514.07	15422.16	15.42	

J	January-01	0.12	0.00	290.48	9004.74	9.00	
J	February-01	0.10	0.00	236.55	7333.01	7.33	
J	March-01	0.20	0.01	493.11	13807.11	13.81	
J	April-01	0.91	0.03	2207.28	68425.61	68.43	
J	May-01	0.08	0.00	200.99	6029.73	6.03	158.40
Outlet	June-00	0.46	0.01	1124.38	33731.39	33.73	
Outlet	July-00	0.21	0.01	497.90	14937.11	14.94	
Outlet	August-00	0.52	0.01	1247.52	37425.54	37.43	
Outlet	September-00	0.16	0.00	393.69	11810.55	11.81	
Outlet	October-00	0.66	0.02	1602.12	48063.46	48.06	
Outlet	November-00	0.90	0.03	2183.75	65512.64	65.51	
Outlet	December-00	1.08	0.03	2600.85	78025.55	78.03	
Outlet	January-01	1.14	0.03	2746.01	82380.32	82.38	
Outlet	February-01	1.14	0.03	2761.44	82843.09	82.84	
Outlet	March-01	1.28	0.04	3102.68	93080.25	93.08	
Outlet	April-01	3.15	0.09	7609.53	228285.91	228.29	
Outlet	May-01	1.00	0.03	2423.82	72714.69	72.71	848.81

Day	Precip (in)	Precip (m)	Direct Watershed Volume (m3)	Direct Lake Precip (m3)	Watershed Volume (L)	Direct Lake Volume (L)
1-Jun	0	0.0000	0.00	0.00	0.00	0.00
2-Jun	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
3-Jun	0	0.0000	0.00	0.00	0.00	0.00
4-Jun	0	0.0000	0.00	0.00	0.00	0.00
5-Jun	0	0.0000	0.00	0.00	0.00	0.00
6-Jun	0.43	0.0109	34413.05	4592.70	34413053.69	4592701.00
7-Jun	0	0.0000	0.00	0.00	0.00	0.00
8-Jun	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
9-Jun	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
10-Jun	0.01	0.0003	800.30	106.81	800303.57	106807.00
11-Jun	0.48	0.0122	38414.57	5126.74	38414571.56	5126736.00
12-Jun	0.01	0.0003	800.30	106.81	800303.57	106807.00
13-Jun	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
14-Jun	0	0.0000	0.00	0.00	0.00	0.00
15-Jun	0	0.0000	0.00	0.00	0.00	0.00
16-Jun	0	0.0000	0.00	0.00	0.00	0.00
17-Jun	0.13	0.0033	10403.95	1388.49	10403946.46	1388491.00
18-Jun	0.12	0.0030	9603.64	1281.68	9603642.89	1281684.00
19-Jun	0.01	0.0003	800.30	106.81	800303.57	106807.00
20-Jun	0	0.0000	0.00	0.00	0.00	0.00
21-Jun	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
22-Jun	0.11	0.0028	8803.34	1174.88	8803339.32	1174877.00
23-Jun	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
24-Jun	0	0.0000	0.00	0.00	0.00	0.00
25-Jun	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
26-Jun	0	0.0000	0.00	0.00	0.00	0.00
27-Jun	0.33	0.0084	26410.02	3524.63	26410017.95	3524631.00
28-Jun	0.01	0.0003	800.30	106.81	800303.57	106807.00
29-Jun	0.22	0.0056	17606.68	2349.75	17606678.63	2349754.00
30-Jun	0.29	0.0074	23208.80	3097.40	23208803.65	3097403.00
Total	**2.43**	**0.0617**	**194473.7685**	**25954.101**	**194473768.5**	**25954101**
Mean	**0.081**	**0.0021**	**6482.458951**	**865.1367**	**6482458.951**	**865136.7**
St Dev	**0.133658082**	**0.0034**	**10696.70404**	**1427.561871**	**10696704.04**	**1427561.871**
1-Jul	0	0.0000	0.00	0.00	0.00	0.00
2-Jul	0.01	0.0003	800.30	106.81	800303.57	106807.00
3-Jul	0.34	0.0086	27210.32	3631.44	27210321.52	3631438.00
4-Jul	0.38	0.0097	30411.54	4058.67	30411535.82	4058666.00
5-Jul	0	0.0000	0.00	0.00	0.00	0.00
6-Jul	0	0.0000	0.00	0.00	0.00	0.00
7-Jul	0	0.0000	0.00	0.00	0.00	0.00
8-Jul	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
9-Jul	0.06	0.0015	4801.82	640.84	4801821.44	640842.00
10-Jul	0.06	0.0015	4801.82	640.84	4801821.44	640842.00
11-Jul	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
12-Jul	0	0.0000	0.00	0.00	0.00	0.00
13-Jul	0	0.0000	0.00	0.00	0.00	0.00
14-Jul	0.27	0.0069	21608.20	2883.79	21608196.50	2883789.00
15-Jul	0	0.0000	0.00	0.00	0.00	0.00
16-Jul	0.47	0.0119	37614.27	5019.93	37614267.98	5019929.00
17-Jul	0	0.0000	0.00	0.00	0.00	0.00
18-Jul	0.62	0.0157	49618.82	6622.03	49618821.60	6622034.00
19-Jul	0	0.0000	0.00	0.00	0.00	0.00
20-Jul	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
21-Jul	0.02	0.0005	1600.61	213.61	1600607.15	213614.00

22-Jul	0.38	0.0097	30411.54	4058.67	30411535.82	4058666.00
23-Jul	0.01	0.0003	800.30	106.81	800303.57	106807.00
24-Jul	0.01	0.0003	800.30	106.81	800303.57	106807.00
25-Jul	0	0.0000	0.00	0.00	0.00	0.00
26-Jul	0	0.0000	0.00	0.00	0.00	0.00
27-Jul	0	0.0000	0.00	0.00	0.00	0.00
28-Jul	0.75	0.0191	60022.77	8010.53	60022768.06	8010525.00
29-Jul	0.1	0.0025	8003.04	1068.07	8003035.74	1068070.00
30-Jul	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
31-Jul	0	0.0000	0.00	0.00	0.00	0.00
Total	**3.58**	**0.0909**	**286508.6795**	**38236.906**	**286508679.5**	**38236906**
Mean	**0.115483871**	**0.0029**	**9242.215469**	**1233.448581**	**9242215.469**	**1233448.581**
St Dev	**0.204301064**	**0.0052**	**16350.28717**	**2182.078374**	**16350287.17**	**2182078.374**
1-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
2-Aug	0	0.0000	0.00	0.00	0.00	0.00
3-Aug	0.63	0.0160	50419.13	6728.84	50419125.17	6728841.00
4-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
5-Aug	0	0.0000	0.00	0.00	0.00	0.00
6-Aug	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
7-Aug	0.48	0.0122	38414.57	5126.74	38414571.56	5126736.00
8-Aug	0	0.0000	0.00	0.00	0.00	0.00
9-Aug	0.26	0.0066	20807.89	2776.98	20807892.93	2776982.00
10-Aug	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
11-Aug	0.15	0.0038	12004.55	1602.11	12004553.61	1602105.00
12-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
13-Aug	0	0.0000	0.00	0.00	0.00	0.00
14-Aug	0.9	0.0229	72027.32	9612.63	72027321.67	9612630.00
15-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
16-Aug	0.44	0.0112	35213.36	4699.51	35213357.26	4699508.00
17-Aug	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
18-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
19-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
20-Aug	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
21-Aug	0	0.0000	0.00	0.00	0.00	0.00
22-Aug	0	0.0000	0.00	0.00	0.00	0.00
23-Aug	0.17	0.0043	13605.16	1815.72	13605160.76	1815719.00
24-Aug	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
25-Aug	0	0.0000	0.00	0.00	0.00	0.00
26-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
27-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
28-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
29-Aug	0	0.0000	0.00	0.00	0.00	0.00
30-Aug	0	0.0000	0.00	0.00	0.00	0.00
31-Aug	0.01	0.0003	800.30	106.81	800303.57	106807.00
Total	**3.29**	**0.0836**	**263299.8759**	**35139.503**	**263299875.9**	**35139503**
Mean	**0.211935484**	**0.0054**	**16961.27252**	**2263.619323**	**16961272.52**	**2263619.323**
St Dev	**0.609412786**	**0.0155**	**48771.52304**	**6508.955139**	**48771523.04**	**6508955.139**
1-Sep	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
2-Sep	0.42	0.0107	33612.75	4485.89	33612750.11	4485894.00
3-Sep	0.06	0.0015	4801.82	640.84	4801821.44	640842.00
4-Sep	0.21	0.0053	16806.38	2242.95	16806375.06	2242947.00
5-Sep	0	0.0000	0.00	0.00	0.00	0.00
6-Sep	0	0.0000	0.00	0.00	0.00	0.00
7-Sep	0	0.0000	0.00	0.00	0.00	0.00
8-Sep	0	0.0000	0.00	0.00	0.00	0.00

9-Sep	0	0.0000	0.00	0.00	0.00	0.00
10-Sep	0.01	0.0003	800.30	106.81	800303.57	106807.00
11-Sep	0	0.0000	0.00	0.00	0.00	0.00
12-Sep	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
13-Sep	0.12	0.0030	9603.64	1281.68	9603642.89	1281684.00
14-Sep	0	0.0000	0.00	0.00	0.00	0.00
15-Sep	0.96	0.0244	76829.14	10253.47	76829143.12	10253472.00
16-Sep	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
17-Sep	0	0.0000	0.00	0.00	0.00	0.00
18-Sep	0.01	0.0003	800.30	106.81	800303.57	106807.00
19-Sep	0	0.0000	0.00	0.00	0.00	0.00
20-Sep	0.2	0.0051	16006.07	2136.14	16006071.48	2136140.00
21-Sep	0.1	0.0025	8003.04	1068.07	8003035.74	1068070.00
22-Sep	0	0.0000	0.00	0.00	0.00	0.00
23-Sep	0.11	0.0028	8803.34	1174.88	8803339.32	1174877.00
24-Sep	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
25-Sep	0	0.0000	0.00	0.00	0.00	0.00
26-Sep	0	0.0000	0.00	0.00	0.00	0.00
27-Sep	0	0.0000	0.00	0.00	0.00	0.00
28-Sep	0	0.0000	0.00	0.00	0.00	0.00
29-Sep	0	0.0000	0.00	0.00	0.00	0.00
30-Sep	0	0.0000	0.00	0.00	0.00	0.00
Total	**2.37**	**0.0602**	**189671.9471**	**25313.259**	**189671947.1**	**25313259**
Mean	**0.079**	**0.0020**	**6322.398236**	**843.7753**	**6322398.236**	**843775.3**
St Dev	**0.189652132**	**0.0048**	**15177.92788**	**2025.617522**	**15177927.88**	**2025617.522**
1-Oct	0	0.0000	0.00	0.00	0.00	0.00
2-Oct	0	0.0000	0.00	0.00	0.00	0.00
3-Oct	0	0.0000	0.00	0.00	0.00	0.00
4-Oct	0.14	0.0036	11204.25	1495.30	11204250.04	1495298.00
5-Oct	0.49	0.0124	39214.88	5233.54	39214875.13	5233543.00
6-Oct	0.28	0.0071	22408.50	2990.60	22408500.08	2990596.00
7-Oct	0.08	0.0020	6402.43	854.46	6402428.59	854456.00
8-Oct	0.22	0.0056	17606.68	2349.75	17606678.63	2349754.00
9-Oct	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
10-Oct	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
11-Oct	0	0.0000	0.00	0.00	0.00	0.00
12-Oct	0	0.0000	0.00	0.00	0.00	0.00
13-Oct	0	0.0000	0.00	0.00	0.00	0.00
14-Oct	0	0.0000	0.00	0.00	0.00	0.00
15-Oct	0	0.0000	0.00	0.00	0.00	0.00
16-Oct	0.11	0.0028	8803.34	1174.88	8803339.32	1174877.00
17-Oct	0	0.0000	0.00	0.00	0.00	0.00
18-Oct	0.46	0.0117	36813.96	4913.12	36813964.41	4913122.00
19-Oct	0	0.0000	0.00	0.00	0.00	0.00
20-Oct	0	0.0000	0.00	0.00	0.00	0.00
21-Oct	0	0.0000	0.00	0.00	0.00	0.00
22-Oct	0	0.0000	0.00	0.00	0.00	0.00
23-Oct	0	0.0000	0.00	0.00	0.00	0.00
24-Oct	0	0.0000	0.00	0.00	0.00	0.00
25-Oct	0	0.0000	0.00	0.00	0.00	0.00
26-Oct	0	0.0000	0.00	0.00	0.00	0.00
27-Oct	0.01	0.0003	800.30	106.81	800303.57	106807.00
28-Oct	0.01	0.0003	800.30	106.81	800303.57	106807.00
29-Oct	0.13	0.0033	10403.95	1388.49	10403946.46	1388491.00
30-Oct	0.24	0.0061	19207.29	2563.37	19207285.78	2563368.00
31-Oct	0.01	0.0003	800.30	106.81	800303.57	106807.00
Total	2.28	0.0579	182469.2149	24351.996	182469214.9	24351996

Mean	**0.073548387**	**0.0019**	**5886.103707**	**785.5482581**	**5886103.707**	**785548.2581**
St Dev	**0.132854517**	**0.0034**	**10632.39445**	**1418.979235**	**10632394.45**	**1418979.235**
1-Nov	0	0.0000	0.00	0.00	0.00	0.00
2-Nov	0	0.0000	0.00	0.00	0.00	0.00
3-Nov	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
4-Nov	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
5-Nov	0.77	0.0196	61623.38	8224.14	61623375.21	8224139.00
6-Nov	0.06	0.0015	4801.82	640.84	4801821.44	640842.00
7-Nov	0	0.0000	0.00	0.00	0.00	0.00
8-Nov	0	0.0000	0.00	0.00	0.00	0.00
9-Nov	0.01	0.0003	800.30	106.81	800303.57	106807.00
10-Nov	0.66	0.0168	52820.04	7049.26	52820035.89	7049262.00
11-Nov	0.29	0.0074	23208.80	3097.40	23208803.65	3097403.00
12-Nov	0	0.0000	0.00	0.00	0.00	0.00
13-Nov	0	0.0000	0.00	0.00	0.00	0.00
14-Nov	0.57	0.0145	45617.30	6088.00	45617303.73	6087999.00
15-Nov	0.22	0.0056	17606.68	2349.75	17606678.63	2349754.00
16-Nov	0	0.0000	0.00	0.00	0.00	0.00
17-Nov	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
18-Nov	0	0.0000	0.00	0.00	0.00	0.00
19-Nov	0	0.0000	0.00	0.00	0.00	0.00
20-Nov	0	0.0000	0.00	0.00	0.00	0.00
21-Nov	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
22-Nov	0.01	0.0003	800.30	106.81	800303.57	106807.00
23-Nov	0	0.0000	0.00	0.00	0.00	0.00
24-Nov	0	0.0000	0.00	0.00	0.00	0.00
25-Nov	0	0.0000	0.00	0.00	0.00	0.00
26-Nov	0.35	0.0089	28010.63	3738.25	28010625.09	3738245.00
27-Nov	0.21	0.0053	16806.38	2242.95	16806375.06	2242947.00
28-Nov	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
29-Nov	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
30-Nov	0.01	0.0003	800.30	106.81	800303.57	106807.00
Total	**3.41**	**0.0866**	**272903.5188**	**36421.187**	**272903518.8**	**36421187**
Mean	**0.113666667**	**0.0029**	**9096.783959**	**1214.039567**	**9096783.959**	**1214039.567**
St Dev	**0.210048982**	**0.0053**	**16810.29508**	**2243.470159**	**16810295.08**	**2243470.159**
1-Dec	0.01	0.0003	800.30	106.81	800303.57	106807.00
2-Dec	0	0.0000	0.00	0.00	0.00	0.00
3-Dec	0	0.0000	0.00	0.00	0.00	0.00
4-Dec	0	0.0000	0.00	0.00	0.00	0.00
5-Dec	0	0.0000	0.00	0.00	0.00	0.00
6-Dec	0	0.0000	0.00	0.00	0.00	0.00
7-Dec	0	0.0000	0.00	0.00	0.00	0.00
8-Dec	0	0.0000	0.00	0.00	0.00	0.00
9-Dec	0	0.0000	0.00	0.00	0.00	0.00
10-Dec	0	0.0000	0.00	0.00	0.00	0.00
11-Dec	0.01	0.0003	800.30	106.81	800303.57	106807.00
12-Dec	0.22	0.0056	17606.68	2349.75	17606678.63	2349754.00
13-Dec	0	0.0000	0.00	0.00	0.00	0.00
14-Dec	0	0.0000	0.00	0.00	0.00	0.00
15-Dec	0.19	0.0048	15205.77	2029.33	15205767.91	2029333.00
16-Dec	0.19	0.0048	15205.77	2029.33	15205767.91	2029333.00
17-Dec	1.68	0.0427	134451.00	17943.58	134451000.46	17943576.00
18-Dec	0.01	0.0003	800.30	106.81	800303.57	106807.00
19-Dec	0	0.0000	0.00	0.00	0.00	0.00
20-Dec	0	0.0000	0.00	0.00	0.00	0.00

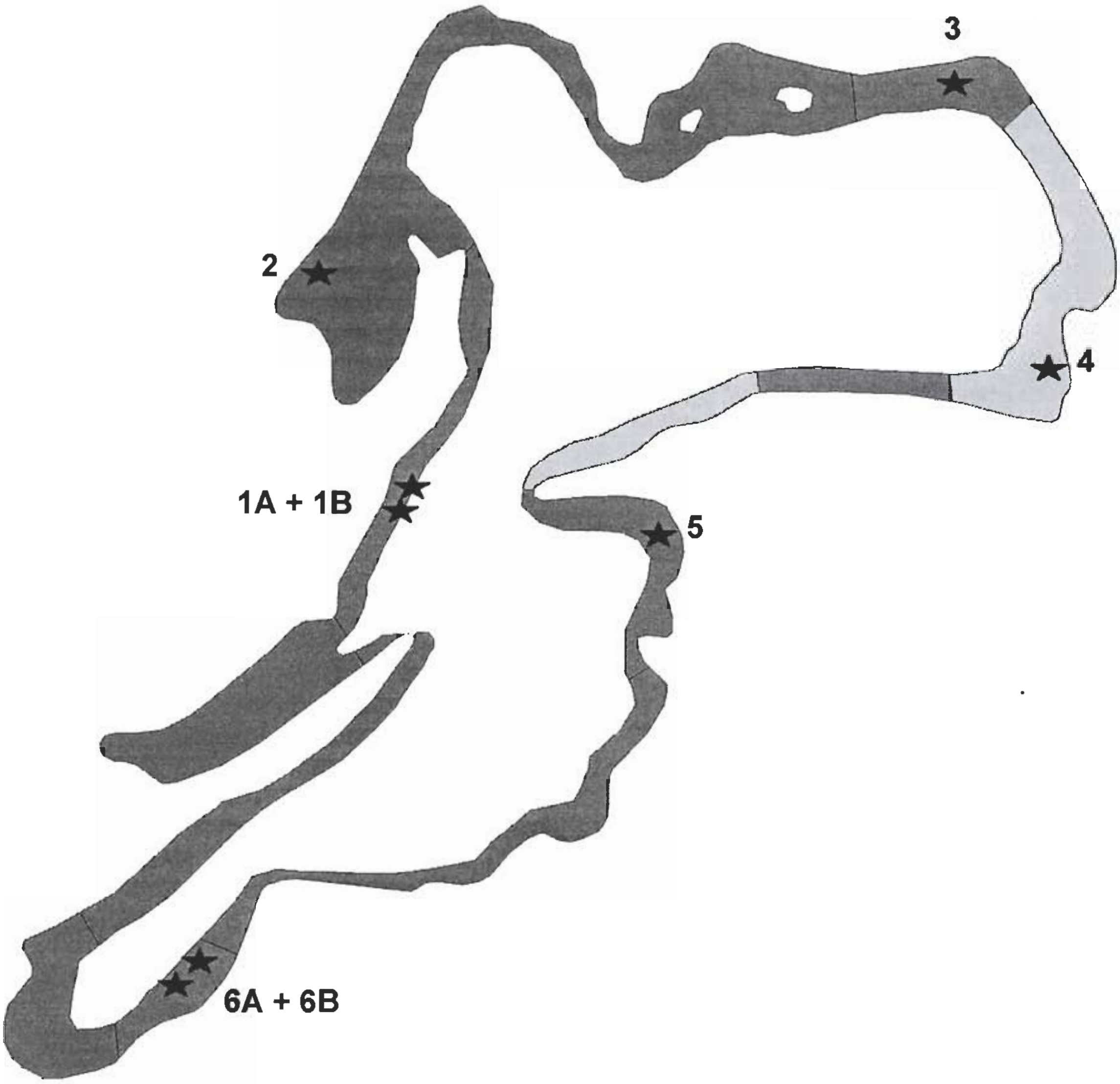
21-Dec	0	0.0000	0.00	0.00	0.00	0.00
22-Dec	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
23-Dec	0	0.0000	0.00	0.00	0.00	0.00
24-Dec	0	0.0000	0.00	0.00	0.00	0.00
25-Dec	0	0.0000	0.00	0.00	0.00	0.00
26-Dec	0	0.0000	0.00	0.00	0.00	0.00
27-Dec	0	0.0000	0.00	0.00	0.00	0.00
28-Dec	0	0.0000	0.00	0.00	0.00	0.00
29-Dec	0	0.0000	0.00	0.00	0.00	0.00
30-Dec	0	0.0000	0.00	0.00	0.00	0.00
31-Dec	0	0.0000	0.00	0.00	0.00	0.00
Total	**2.35**	**0.0597**	**188071.3399**	**25099.645**	**188071339.9**	**25099645**
Mean	**0.075806452**	**0.0019**	**6066.817417**	**809.6659677**	**6066817.417**	**809665.9677**
St Dev	**0.303685958**	**0.0077**	**24304.09579**	**3243.578615**	**24304095.79**	**3243578.615**
1-Jan	0	0.0000	0.00	0.00	0.00	0.00
2-Jan	0	0.0000	0.00	0.00	0.00	0.00
3-Jan	0	0.0000	0.00	0.00	0.00	0.00
4-Jan	0	0.0000	0.00	0.00	0.00	0.00
5-Jan	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
6-Jan	0	0.0000	0.00	0.00	0.00	0.00
7-Jan	0	0.0000	0.00	0.00	0.00	0.00
8-Jan	0.01	0.0003	800.30	106.81	800303.57	106807.00
9-Jan	0	0.0000	0.00	0.00	0.00	0.00
10-Jan	0	0.0000	0.00	0.00	0.00	0.00
11-Jan	0	0.0000	0.00	0.00	0.00	0.00
12-Jan	0	0.0000	0.00	0.00	0.00	0.00
13-Jan	0	0.0000	0.00	0.00	0.00	0.00
14-Jan	0	0.0000	0.00	0.00	0.00	0.00
15-Jan	0	0.0000	0.00	0.00	0.00	0.00
16-Jan	0.01	0.0003	800.30	106.81	800303.57	106807.00
17-Jan	0	0.0000	0.00	0.00	0.00	0.00
18-Jan	0	0.0000	0.00	0.00	0.00	0.00
19-Jan	0	0.0000	0.00	0.00	0.00	0.00
20-Jan	0	0.0000	0.00	0.00	0.00	0.00
21-Jan	0	0.0000	0.00	0.00	0.00	0.00
22-Jan	0	0.0000	0.00	0.00	0.00	0.00
23-Jan	0	0.0000	0.00	0.00	0.00	0.00
24-Jan	0	0.0000	0.00	0.00	0.00	0.00
25-Jan	0	0.0000	0.00	0.00	0.00	0.00
26-Jan	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
27-Jan	0.01	0.0003	800.30	106.81	800303.57	106807.00
28-Jan	0	0.0000	0.00	0.00	0.00	0.00
29-Jan	0	0.0000	0.00	0.00	0.00	0.00
30-Jan	0	0.0000	0.00	0.00	0.00	0.00
31-Jan	0	0.0000	0.00	0.00	0.00	0.00
Total	**0.09**	**0.0023**	**7202.732167**	**961.263**	**7202732.167**	**961263**
Mean	**0.002903226**	**0.0001**	**232.3461989**	**31.00848387**	**232346.1989**	**31008.48387**
St Dev	**0.008243603**	**0.0002**	**659.7384888**	**88.0474498**	**659738.4888**	**88047.4498**
1-Feb	0	0.0000	0.00	0.00	0.00	0.00
2-Feb	0	0.0000	0.00	0.00	0.00	0.00
3-Feb	0	0.0000	0.00	0.00	0.00	0.00
4-Feb	0	0.0000	0.00	0.00	0.00	0.00
5-Feb	0	0.0000	0.00	0.00	0.00	0.00
6-Feb	0	0.0000	0.00	0.00	0.00	0.00
7-Feb	0	0.0000	0.00	0.00	0.00	0.00

8-Feb	0	0.0000	0.00	0.00	0.00	0.00
9-Feb	0	0.0000	0.00	0.00	0.00	0.00
10-Feb	1.75	0.0445	140053.13	18691.23	140053125.47	18691225.00
11-Feb	0	0.0000	0.00	0.00	0.00	0.00
12-Feb	0	0.0000	0.00	0.00	0.00	0.00
13-Feb	0	0.0000	0.00	0.00	0.00	0.00
14-Feb	0	0.0000	0.00	0.00	0.00	0.00
15-Feb	0.06	0.0015	4801.82	640.84	4801821.44	640842.00
16-Feb	0	0.0000	0.00	0.00	0.00	0.00
17-Feb	0	0.0000	0.00	0.00	0.00	0.00
18-Feb	0	0.0000	0.00	0.00	0.00	0.00
19-Feb	0	0.0000	0.00	0.00	0.00	0.00
20-Feb	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
21-Feb	0.01	0.0003	800.30	106.81	800303.57	106807.00
22-Feb	0.01	0.0003	800.30	106.81	800303.57	106807.00
23-Feb	0.1	0.0025	8003.04	1068.07	8003035.74	1068070.00
24-Feb	0	0.0000	0.00	0.00	0.00	0.00
25-Feb	0.19	0.0048	15205.77	2029.33	15205767.91	2029333.00
26-Feb	0.01	0.0003	800.30	106.81	800303.57	106807.00
27-Feb	0	0.0000	0.00	0.00	0.00	0.00
28-Feb	0	0.0000	0.00	0.00	0.00	0.00
Total	**2.16**	**0.0549**	**172865.572**	**23070.312**	**172865572**	**23070312**
Mean	**0.077142857**	**0.0020**	**6173.770429**	**823.9397143**	**6173770.429**	**823939.7143**
St Dev	**0.330362956**	**0.0084**	**26439.06543**	**3528.507622**	**26439065.43**	**3528507.622**
1-Mar	0	0.0000	0.00	0.00	0.00	0.00
2-Mar	0.01	0.0003	800.30	106.81	800303.57	106807.00
3-Mar	0	0.0000	0.00	0.00	0.00	0.00
4-Mar	0	0.0000	0.00	0.00	0.00	0.00
5-Mar	0.18	0.0046	14405.46	1922.53	14405464.33	1922526.00
6-Mar	0.28	0.0071	22408.50	2990.60	22408500.08	2990596.00
7-Mar	0	0.0000	0.00	0.00	0.00	0.00
8-Mar	0	0.0000	0.00	0.00	0.00	0.00
9-Mar	0.12	0.0030	9603.64	1281.68	9603642.89	1281684.00
10-Mar	0.01	0.0003	800.30	106.81	800303.57	106807.00
11-Mar	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
12-Mar	0	0.0000	0.00	0.00	0.00	0.00
13-Mar	0.23	0.0058	18406.98	2456.56	18406982.21	2456561.00
14-Mar	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
15-Mar	0.01	0.0003	800.30	106.81	800303.57	106807.00
16-Mar	0	0.0000	0.00	0.00	0.00	0.00
17-Mar	0	0.0000	0.00	0.00	0.00	0.00
18-Mar	0	0.0000	0.00	0.00	0.00	0.00
19-Mar	0	0.0000	0.00	0.00	0.00	0.00
20-Mar	0	0.0000	0.00	0.00	0.00	0.00
21-Mar	0	0.0000	0.00	0.00	0.00	0.00
22-Mar	0.56	0.0142	44817.00	5981.19	44817000.15	5981192.00
23-Mar	0.16	0.0041	12804.86	1708.91	12804857.19	1708912.00
24-Mar	0	0.0000	0.00	0.00	0.00	0.00
25-Mar	0	0.0000	0.00	0.00	0.00	0.00
26-Mar	0	0.0000	0.00	0.00	0.00	0.00
27-Mar	0	0.0000	0.00	0.00	0.00	0.00
28-Mar	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
29-Mar	0	0.0000	0.00	0.00	0.00	0.00
30-Mar	0.08	0.0020	6402.43	854.46	6402428.59	854456.00
31-Mar	0.3	0.0076	24009.11	3204.21	24009107.22	3204210.00
Total	**2.11**	**0.0536**	168864.0541	**22536.277**	**168864054.1**	**22536277**
Mean	0.068064516	0.0017	5447.227553	**726.9766774**	**5447227.553**	**726976.6774**

St Dev	**0.126633838**	**0.0032**	**10134.55135**	**1352.538038**	**10134551.35**	**1352538.038**
1-Apr	0.03	0.0008	2400.91	320.42	2400910.72	320421.00
2-Apr	0	0.0000	0.00	0.00	0.00	0.00
3-Apr	0	0.0000	0.00	0.00	0.00	0.00
4-Apr	0	0.0000	0.00	0.00	0.00	0.00
5-Apr	0	0.0000	0.00	0.00	0.00	0.00
6-Apr	0.11	0.0028	8803.34	1174.88	8803339.32	1174877.00
7-Apr	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
8-Apr	0.33	0.0084	26410.02	3524.63	26410017.95	3524631.00
9-Apr	0	0.0000	0.00	0.00	0.00	0.00
10-Apr	0	0.0000	0.00	0.00	0.00	0.00
11-Apr	0	0.0000	0.00	0.00	0.00	0.00
12-Apr	0.32	0.0081	25609.71	3417.82	25609714.37	3417824.00
13-Apr	0.01	0.0003	800.30	106.81	800303.57	106807.00
14-Apr	0	0.0000	0.00	0.00	0.00	0.00
15-Apr	0	0.0000	0.00	0.00	0.00	0.00
16-Apr	0	0.0000	0.00	0.00	0.00	0.00
17-Apr	0	0.0000	0.00	0.00	0.00	0.00
18-Apr	0	0.0000	0.00	0.00	0.00	0.00
19-Apr	0	0.0000	0.00	0.00	0.00	0.00
20-Apr	0	0.0000	0.00	0.00	0.00	0.00
21-Apr	0.04	0.0010	3201.21	427.23	3201214.30	427228.00
22-Apr	0.11	0.0028	8803.34	1174.88	8803339.32	1174877.00
23-Apr	0.01	0.0003	800.30	106.81	800303.57	106807.00
24-Apr	0.07	0.0018	5602.13	747.65	5602125.02	747649.00
25-Apr	0	0.0000	0.00	0.00	0.00	0.00
26-Apr	0	0.0000	0.00	0.00	0.00	0.00
27-Apr	0	0.0000	0.00	0.00	0.00	0.00
28-Apr	0	0.0000	0.00	0.00	0.00	0.00
29-Apr	0	0.0000	0.00	0.00	0.00	0.00
30-Apr	0	0.0000	0.00	0.00	0.00	0.00
Total	**1.05**	**0.0267**	**84031.87528**	**11214.735**	**84031875.28**	**11214735**
Mean	**0.035**	**0.0009**	**2801.062509**	**373.8245**	**2801062.509**	**373824.5**
St Dev	**0.084435243**	**0.0021**	**6757.382716**	**901.8275052**	**6757382.716**	**901827.5052**
1-May	0	0.0000	0.00	0.00	0.00	0.00
2-May	0.01	0.0003	800.30	106.81	800303.57	106807.00
3-May	0	0.0000	0.00	0.00	0.00	0.00
4-May	0	0.0000	0.00	0.00	0.00	0.00
5-May	0.01	0.0003	800.30	106.81	800303.57	106807.00
6-May	0	0.0000	0.00	0.00	0.00	0.00
7-May	0	0.0000	0.00	0.00	0.00	0.00
8-May	0	0.0000	0.00	0.00	0.00	0.00
9-May	0	0.0000	0.00	0.00	0.00	0.00
10-May	0	0.0000	0.00	0.00	0.00	0.00
11-May	0	0.0000	0.00	0.00	0.00	0.00
12-May	0.75	0.0191	60022.77	8010.53	60022768.06	8010525.00
13-May	0	0.0000	0.00	0.00	0.00	0.00
14-May	0	0.0000	0.00	0.00	0.00	0.00
15-May	0	0.0000	0.00	0.00	0.00	0.00
16-May	0	0.0000	0.00	0.00	0.00	0.00
17-May	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
18-May	0.14	0.0036	11204.25	1495.30	11204250.04	1495298.00
19-May	0.02	0.0005	1600.61	213.61	1600607.15	213614.00
20-May	0	0.0000	0.00	0.00	0.00	0.00

21-May	0	0.0000	0.00	0.00	0.00	0.00
22-May	0	0.0000	0.00	0.00	0.00	0.00
23-May	0	0.0000	0.00	0.00	0.00	0.00
24-May	0	0.0000	0.00	0.00	0.00	0.00
25-May	0.01	0.0003	800.30	106.81	800303.57	106807.00
26-May	0.29	0.0074	23208.80	3097.40	23208803.65	3097403.00
27-May	0.52	0.0132	41615.79	5553.96	41615785.86	5553964.00
28-May	0.08	0.0020	6402.43	854.46	6402428.59	854456.00
29-May	0.05	0.0013	4001.52	534.04	4001517.87	534035.00
30-May	0.01	0.0003	800.30	106.81	800303.57	106807.00
31-May	0	0.0000	0.00	0.00	0.00	0.00
Total	**1.91**	**0.0485**	**152857.9827**	**20400.137**	**152857982.7**	**20400137**
Mean	**0.061612903**	**0.0016**	**4930.902666**	**658.0689355**	**4930902.666**	**658068.9355**
St Dev	**0.166234709**	**0.0042**	**13303.82318**	**1775.503057**	**13303823.18**	**1775503.057**
	acres					
Lake Area	103.63					
Watershed Area	801.71					

Nearshore Groundwater Seepage Sample Locations and Substrate Types



Seepage Zone	Substrate Type	Area (m2)
	Muck (0.5-1ft)	67690
	Sand	25532
	Silty Muck (.5-1ft)	22752
	Muck (1.5-2 ft)	32950

★ Seepage Location

Elapsed Time	Minutes	Final Volume (ml)	mls/min	mls/m2/min	L/m2/min	L/m2/d	Lake Seepage (L/d)	Lake Seepage (m^3/d)	barrel area
1:14:18	74	90	1.2	4.5045	0.0045	6.4865	439055.4811	439.0554811	.27m2
1:03:55	64	89	1.4	5.1505	0.0052	7.4167	502017.2567	502.0172567	
1:27:05	87	50	0.6	2.1286	0.0021	3.0651	207471.9387	207.4719387	
2:47:57	168	84	0.5	1.8519	0.0019	2.6667	180500.5867	180.5005867	
1:16:39	76	135	1.8	6.5789	0.0066	9.4737	641252.0842	641.2520842	
1:59:46	120	204	1.7	6.2963	0.0063	9.0667	613701.9947	613.7019947	
0:58:57	59	100	1.7	6.2775	0.0063	9.0395	611866.3955	611.8663955	
						47.2149	**3195865.7375**	**3195.8657**	
						6.7450	**456552.2482**	**456.5522**	
						2.8517	**193024.7311**	**193.0247**	
							Area=67687.72		
1:07:20	67	5	0.1	0.2764	0.0003	0.3980	10161.8388	10.16183881	
1:03:33	63	15	0.2	0.8818	0.0009	1.2698	32421.1048	32.42110476	
1:32:59	93	164	1.8	6.5313	0.0065	9.4050	240125.3437	240.1253437	
1:44:40	102	120	1.2	4.3573	0.0044	6.2745	160198.4000	160.1984	
1:22:07	88	148	1.7	6.2290	0.0062	8.9697	229010.8945	229.0108945	
2:01:28	121	49	0.4	1.4998	0.0015	2.1598	55142.6724	55.1426724	
1:00:51	61	73	1.2	4.4323	0.0044	6.3825	162955.9134	162.9559134	
						34.8594	**890016.1676**	**890.0162**	
						4.9799	**127145.1668**	**127.1452**	
						3.6936	**94302.8621**	**94.3029**	
							Area=25531.62		
1:02:35	62	0	0.0	0.0000	0.0000	0.0000	0.0000	0	
1:02:48	63	14	0.2	0.8230	0.0008	1.1852	26964.6578	26.96465778	
1:27:42	87	185	2.1	7.8757	0.0079	11.3410	258023.8805	258.0238805	
1:42:32	102	222	2.2	8.0610	0.0081	11.6078	264095.0306	264.0950306	
1:21:28	81	172	2.1	7.8647	0.0079	11.3251	257662.2854	257.6622854	
1:12:04	72	44	0.6	2.2634	0.0023	3.2593	74152.8089	74.15280889	
1:02:08	62	50	0.8	2.9869	0.0030	4.3011	97855.6129	97.8556129	
						43.0195	**978754.2760**	**978.7543**	
						6.1456	**139822.0394**	**139.8220**	
						5.1277	**116663.6156**	**116.6636**	
							Area=22751.43m^2		
1:00:17	60	209	3.5	12.9012	0.0129	18.5778	612128.4889	612.1284889	
1:04:08	64	140	2.2	8.1019	0.0081	11.6667	384410.8333	384.4108333	
1:25:52	86	200	2.3	8.6133	0.0086	12.4031	408675.9690	408.675969	
1:42:40	102	65	0.6	2.3602	0.0024	3.3987	111985.2288	111.9852288	
1:18:43	79	35	0.4	1.6409	0.0016	2.3629	77855.3586	77.85535865	
1:22:58	83	164	2.0	7.3182	0.0073	10.5382	347226.8594	347.2268594	
1:05:59	66	165	2.5	9.2593	0.0093	13.3333	439326.6667	439.3266667	
						72.2806	**2381609.4047**	**2381.6094**	
						10.3258	**340229.9150**	**340.2299**	
						5.6964	**187692.4871**	**187.6925**	
							Area=32949.50m^2		

Elapsed Time	Minutes	Final Volume (ml)	mls/min	mls/m2/min	L/m2/min	L/m2/d	Lake Seepage (L/d)	Lake Seepage (m^3/d)	barrel area
1:17:00	77	200	2.6	9.6200	0.0096	13.8528	353684.7792	353.6847792	
1:03:27	63	111	1.8	6.5256	0.0065	9.3968	239916.1752	239.9161752	
1:26:38	86	30	0.3	1.2920	0.0013	1.8605	47500.6884	47.50068837	
2:48:45	168	236	1.4	5.2028	0.0052	7.4921	191284.5181	191.2845181	
1:14:18	74	98	1.3	4.9049	0.0049	7.0631	180331.4422	180.3314422	
1:59:52	120	200	1.7	6.1728	0.0062	8.8889	226947.7333	226.9477333	
1:00:19	60	210	3.5	12.9630	0.0130	18.6667	476590.2400	476.59024	
						67.2208	**1716255.5764**	**1716.2556**	
						9.6030	**245179.3681**	**245.1794**	
						5.3482	**136547.4755**	**136.5475**	
							Area=25531.62		
1:17:57	78	75	1.0	3.5613	0.0036	5.1282	130931.3846	130.9313846	
1:04:22	64	13	0.2	0.7523	0.0008	1.0833	27659.2550	27.659255	
1:27:14	87	131	1.5	5.5768	0.0056	8.0307	205035.5384	205.0355384	
2:47:52	168	110	0.7	2.4250	0.0024	3.4921	89158.0381	89.1580381	
1:14:50	74	82	1.1	4.1041	0.0041	5.9099	150889.5741	150.8895741	
1:57:40	117	135	1.2	4.2735	0.0043	6.1538	157117.6615	157.1176615	
0:59:03	59	101	1.7	6.3402	0.0063	9.1299	233102.2481	233.1022481	
						38.9280	**993893.6998**	**993.8937**	
						5.5611	**141984.8143**	**141.9848**	
						2.7027	**69003.9352**	**69.0039**	
							Area=25531.62		
1:00:29	60	40	0.7	2.4691	0.0025	3.5556	90779.0933	90.77909333	
1:02:33	62	203	3.3	12.1266	0.0121	17.4624	445842.4826	445.8424826	
1:23:53	84	155	1.8	6.8342	0.0068	9.8413	251263.5619	251.2635619	
1:43:49	104	154	1.5	5.4843	0.0055	7.8974	201634.3323	201.6343323	
1:16:19	76	15	0.2	0.7310	0.0007	1.0526	26875.3895	26.87538947	
1:25:12	85	20	0.2	0.8715	0.0009	1.2549	32039.6800	32.03968	
1:06:52	67	51	0.8	2.8192	0.0028	4.0597	103650.7558	103.6507558	
						45.1239	**1152085.2954**	**1152.0853**	
						6.4463	**164583.6136**	**164.5836**	
						5.8464	**149267.1488**	**149.2671**	
							Area=25531.62		
1:00:43	60	100	1.7	6.1728	0.0062	8.8889	226947.7333	226.9477333	
1:02:01	67	124	1.9	6.8546	0.0069	9.8706	252013.6024	252.0136024	
1:24:25	84	50	0.6	2.2046	0.0022	3.1746	81052.7619	81.0527619	
1:43:23	103	2	0.0	0.0719	0.0001	0.1036	2644.0513	2.644051262	
1:11:48	71	145	2.0	7.5639	0.0076	10.8920	278090.8845	278.0908845	
1:23:40	83	26	0.3	1.1602	0.0012	1.6707	42655.2366	42.65523663	
1:07:08	68	79	1.2	4.3028	0.0043	6.1961	158195.9200	158.19592	
						40.7965	**1041600.1900**	**1041.6002**	
						5.8281	**148800.0271**	**148.8000**	
						4.2541	**108614.3733**	**108.6144**	
							Area=25531.62		

SubName	LandUse_Type	Sum_Acres	Total Acres within 1000 ft watershed (not by lu grid)	
A	Cleared/Other Open	3.3125836		
A	Hay/Rotation/Permanent Pasture	1.2910857		
A	Hemlock	4.30039122		
A	Mixed Forest	3.15254325		
A	Open Water	0.16215326		
A	Other Hardwoods	0.24257537		
A	Paper Birch/Aspen	5.20388165		
A	Spruce/Fir	0.00893621		
A	Transportation	1.88573214		
A	White/Red Pine	1.30817431		
	Total	20.86805671	20.87	
B	Hemlock	6.48736987		
B	Mixed Forest	6.62279651		
B	Non-forested Wetland	5.04403842		
B	Open Water	2.34986137		
B	Other Hardwoods	0.0932074		
B	Paper Birch/Aspen	5.15705599		
B	Transportation	4.15464912		
B	White/Red Pine	8.04535083		
	Total	37.95432951	39.4	
D	Hemlock	2.5726225		
D	Mixed Forest	0.47738962		
D	Non-forested Wetland	1.55731795		
D	Open Water	0.04959859		
D	Other Hardwoods	4.63819514		
D	Paper Birch/Aspen	8.13288562		
D	White/Red Pine	3.09410113		
	Total	20.52211055	20.52	
F	Hemlock	6.06589446		
F	Mixed Forest	4.86116745		
F	Open Water	0.48722182		
F	White/Red Pine	6.28216338		
	Total	17.69644711	17.7	
G	Cleared/Other Open	0.03769758		
G	Hemlock	6.15379566		
G	Mixed Forest	10.19245585		
G	Open Water	0.88027574		
G	Paper Birch/Aspen	0.08232903		
G	Spruce/Fir	1.83652605		
G	White/Red Pine	0.1832886		
	Total	19.36636851	19.37	
H	Hemlock	3.67038374		
H	Mixed Forest	6.01905367		
H	Open Water	1.48893442		
H	Spruce/Fir	2.18554799		
H	White/Red Pine	2.01793399		
	Total	15.38185381	15.39	
I	Cleared/Other Open	0.03729082		
I	Hay/Rotation/Permanent Pasture	0.00448858		
I	Mixed Forest	0.09692924		

I	Open Water	0.19784546		
I	Paper Birch/Aspen	4.1360921		
I	Spruce/Fir	0.63734153		
I	Transportation	2.22020865		
I	White/Red Pine	3.36363728		
	Total	10.69383366	10.69	
J	Beech/Oak	2.30270511		
J	Cleared/Other Open	3.46759442		
J	Mixed Forest	3.25905399		
J	Other Hardwoods	2.61039558		
J	Paper Birch/Aspen	9.36313559		
J	Transportation	0.65667767		
J	White/Red Pine	3.60571898		
	Total	25.26528134	25.27	
K	Beech/Oak	0.7097368		
K	Cleared/Other Open	1.4895191		
K	Open Water	0.70883583		
K	Other Hardwoods	2.18680773		
K	Paper Birch/Aspen	13.28476773		
K	Transportation	3.25022575		
	Total	21.62989294	21.63	
L	Beech/Oak	1.53394834		
L	Cleared/Other Open	0.67961566		
L	Forested Wetland	2.40835002		
L	Hemlock	2.67037571		
L	Mixed Forest	0.71566868		
L	Non-forested Wetland	3.61788994		
L	Open Water	0.00268584		
L	Other Hardwoods	4.32216809		
L	Paper Birch/Aspen	7.63771084		
L	Transportation	0.25878935		
L	White/Red Pine	0.64685247		
	Total	24.49405494	24.49	
P11	Cleared/Other Open	0.45043247		
P11	Hemlock	1.12944216		
P11	Mixed Forest	2.49546458		
P11	Open Water	6.76444072		
P11	White/Red Pine	4.40684189		
	Total	15.24662182	15.25	
P13	Hemlock	2.75830633		
P13	Mixed Forest	0.68981229		
P13	Open Water	0.37480577		
P13	Other Hardwoods	0.00072505		
P13	Paper Birch/Aspen	2.69006785		
P13	White/Red Pine	3.2873637		
	Total	9.80108099	9.8	
P14	Open Water	4.59703247		
P14	White/Red Pine	0.74243685		
	Total	5.33946932	5.5	
E	Hemlock	3.37140796		
E	Mixed Forest	4.33643612		
E	Open Water	0.07351793		

E	Paper Birch/Aspen	0.0408651		
E	White/Red Pine	3.96730269		
	Total	11.7895298	11.79	
P4	Cleared/Other Open	4.47716085		
P4	Mixed Forest	0.3995782		
P4	Open Water	2.19413459		
P4	Paper Birch/Aspen	1.02038284		
P4	Transportation	1.78851656		
P4	White/Red Pine	0.04244173		
	Total	9.92221477	9.92	
P5	Cleared/Other Open	0.20412102		
P5	Open Water	0.57164101		
P5	Paper Birch/Aspen	2.469426		
P5	Spruce/Fir	0.02762		
P5	Transportation	3.2480368		
P5	White/Red Pine	1.26230561		
	Total	7.78315044	7.78	
P6	Beech/Oak	2.26830964		
P6	Cleared/Other Open	0.21870852		
P6	Open Water	0.10162121		
P6	Other Hardwoods	3.40131426		
P6	Paper Birch/Aspen	5.60280405		
P6	Transportation	0.71463126		
	Total	12.30738894	12.31	
			287.68	1163953
			acres	m2
			558697.5744	
	% Precip	Monthly RO (103m3)	runoff (m3)	
June-00	0.09	49.2968448	0.48 m RO per Knox/Nordensen	
July-00	0.13	73.9452672		
August-00	0.12	65.7291264		
September-00	0.09	49.2968448		
October-00	0.09	49.2968448		
November-00	0.13	73.9452672		
December-00	0.09	49.2968448		
January-01	0.00	0		
February-01	0.07	41.080704		
March-01	0.07	41.080704		
April-01	0.04	24.6484224		
1-May	0.07	41.080704		

Appendix Two

Nutrient Budget Raw Data and Calculations

Partidge Lake

Tributary	Month	Flow (cfs)	Flow (m3/s)	Flow (m3/d)	Flow (m3/mo)	103m3	Liters	Mean monthly TP (ug/L)	TP (ug)	TP (Kg)
A	June-00	0.14	0.00	336.10	10083.13	10.08	10083128.83	9	90748159.5	0.090748159
A	July-00	0.03	0.00	83.91	2601.17	2.60	2601171.01	11	28612881.2	0.028612881
A	August-00	0.11	0.00	256.62	7955.07	7.96	7955070.84	7	55685495.9	0.055685496
A	September-00	0.15	0.00	354.25	10627.59	10.63	10627593.98	6	63765563.9	0.063765564
A	October-00	0.27	0.01	643.72	19955.17	19.96	19955172.79	7	139686210	0.13968621
A	November-00	0.26	0.01	639.97	19199.16	19.20	19199158.27	6	115194950	0.11519495
A	December-00	0.15	0.00	367.78	11401.27	11.40	11401270.27	8	91210162.2	0.091210162
A	January-01	0.15	0.00	367.78	11401.27	11.40	11401270.27	8.5	96910797.3	0.096910797
A	February-01	0.16	0.00	390.26	10927.16	10.93	10927158.68	10	109271587	0.109271587
A	March-01	0.11	0.00	266.11	8249.47	8.25	8249472.00	11	90744192	0.090744192
A	April-01	0.46	0.01	1107.68	33230.52	33.23	33230518.27	17	564918811	0.564918811
A	May-01	0.07	0.00	174.96	5423.70	5.42	5423702.86	6.00	32542217.2	0.032542217
G	June-00	0.17	0.00	411.26	12337.92	12.34	12337920.00	19	234420480	0.23442048
G	July-00	0.13	0.00	314.50	9749.38	9.75	9749376.00	18	175488768	0.175488768
G	August-00	0.02	0.00	48.38	1499.90	1.50	1499904.00	17	25498368	0.025498368
G	September-00	0.03	0.00	60.83	1824.77	1.82	1824772.56	17	31021133.6	0.031021134
G	October-00	0.04	0.00	104.49	3239.16	3.24	3239157.43	12	38869889.2	0.038869889
G	November-00	0.03	0.00	67.23	2016.79	2.02	2016788.34	7	14117518.4	0.014117518
G	December-00	0.09	0.00	217.51	6742.71	6.74	6742705.94	9	60684353.5	0.060684353
G	January-01	0.10	0.00	246.88	7653.34	7.65	7653344.90	11	84186794	0.084186794
G	February-01	0.07	0.00	180.08	5042.34	5.04	5042335.58	10	50423355.8	0.050423356
G	March-01	0.13	0.00	311.35	9651.85	9.65	9651854.74	11	106170402	0.106170402
G	April-01	0.58	0.02	1401.59	42047.68	42.05	42047684.10	27	1135287471	1.135287471
G	May-01	0.33	0.01	807.33	25027.22	25.03	25027216.66	16.00	400435466	0.400435466
H	June-00	0.08	0.00	181.93	5458.01	5.46	5458005.50	15	81870082.6	0.081870083
H	July-00	0.08	0.00	188.13	5832.13	5.83	5832134.72	12.5	72901684	0.072901684
H	August-00	0.02	0.00	50.80	1574.90	1.57	1574899.20	10	15748992	0.015748992
H	September-00	0.03	0.00	62.32	1869.49	1.87	1869487.36	5	9347436.81	0.009347437
H	October-00	0.08	0.00	200.03	6201.00	6.20	6200997.61	10	62009976.1	0.062009976
H	November-00	0.06	0.00	146.24	4387.09	4.39	4387085.66	5	21935428.3	0.021935428
H	December-00	0.00	0.00	0.00	0.00	0.00	0.00	6	0	0
H	January-01	0.19	0.01	452.70	14033.63	14.03	14033626.79	7	98235387.5	0.098235388
H	February-01	0.00	0.00	0.00	0.00	0.00	0.00	5	0	0
H	March-01	0.00	0.00	0.00	0.00	0.00	0.00	8	0	0
H	April-01	0.29	0.01	692.72	20781.65	20.78	20781653.76	11	228598191	0.228598191
H	May-01	0.01	0.00	15.10	468.00	0.47	468004.55	5.00	2340022.73	0.002340023

J	June-00	0.12	0.00	284.93	8547.98	8.55	8547981.93	8	68383855.4	0.068383855
J	July-00	0.08	0.00	198.74	6160.82	6.16	6160823.43	5	30804117.2	0.030804117
J	August-00	0.05	0.00	122.63	3801.43	3.80	3801430.19	12	45617162.3	0.045617162
J	September-00	0.00	0.00	0.00	0.00	0.00	0.00		0	0
J	October-00	0.11	0.00	267.72	8299.39	8.30	8299390.68	7	58095734.8	0.058095735
J	November-00	0.16	0.00	379.10	11373.11	11.37	11373113.04	5	56865565.2	0.056865565
J	December-00	0.21	0.01	514.07	15936.23	15.94	15936228.02		0	0
J	January-01	0.12	0.00	290.48	9004.74	9.00	9004744.66	27	243128106	0.243128106
J	February-01	0.10	0.00	236.55	6623.37	6.62	6623366.50	6	39740199	0.039740199
J	March-01	0.20	0.01	493.11	15286.45	15.29	15286447.85	8	122291583	0.122291583
J	April-01	0.91	0.03	2207.28	66218.33	66.22	66218327.88	13	860838263	0.860838263
J	May-01	0.08	0.00	200.99	6230.72	6.23	6230716.46	5.00	31153582.3	0.031153582
Outlet	June-00	0.46	0.01	1124.38	33731.39	33.73	33731389.44	10	337313894	0.337313894
Outlet	July-00	0.21	0.01	497.90	15435.02	15.44	15435015.22	9	138915137	0.138915137
Outlet	August-00	0.52	0.01	1247.52	38673.06	38.67	38673059.77	12	464076717	0.464076717
Outlet	September-00	0.16	0.00	393.69	11810.55	11.81	11810551.33	12	141726616	0.141726616
Outlet	October-00	0.66	0.02	1602.12	49665.57	49.67	49665571.20	8	397324570	0.39732457
Outlet	November-00	0.90	0.03	2183.75	65512.64	65.51	65512639.99	14	917176960	0.91717696
Outlet	December-00	1.08	0.03	2600.85	80626.40	80.63	80626402.08	21	1693154444	1.693154444
Outlet	January-01	1.14	0.03	2746.01	85126.33	85.13	85126331.57	36	3064547936	3.064547936
Outlet	February-01	1.14	0.03	2761.44	77320.22	77.32	77320219.25	17	1314443727	1.314443727
Outlet	March-01	1.28	0.04	3102.68	96182.93	96.18	96182928.90	17	1635109791	1.635109791
Outlet	April-01	3.15	0.09	7609.53	228285.91	228.29	228285911.35	11	2511145025	2.511145025
Outlet	May-01	1.00	0.03	2423.82	75138.51	75.14	75138508.33	10.00	751385083	0.751385083

Land Use	**3/I**	**4**	**5**	**6**	**7**	**8/K**	**10/B**	**11**	**12/D**	**13/E**	**15/F**	**16**
Beech/Oak				4.09	8.44	6.49			0.98	2.29		
Cleared/Other	0.12	4.3	0.02	0.14	2.93			0.62	0.93		0.01	
Hay/Rotation/Pasture											2.69	
Hemlock					3.21	0.06	6.96	1.42	17.78		7.47	4.06
Mixed Forest	0.27	0.22		0.26	1.92	0.02	6.53	2.55	38.38	0.79	7.75	2.6
Open Water	0.42	3	1.2	0.13	3.81	0.44	2.42	6.19	0.13	0.95	0.1	0.28
Other Hardwoods				6.11	12.39	5.4	0.33		25.47		1.63	
Paper Birch/Aspen	4.25	0.81	2.57	7.23	21.21	13.11	5.54		43.13	2.36	2.98	
Spruce/Fir	0.71		0.06									
Transportation	2.72		2.72	0.7	0.14	3.12	4.13					
White/Red Pine	4.28	0.01	1.22		0.71		8.14	4.33	34.68	3.41	8.71	1.39
Wetland					2.41				0.92			
Total	**12.77**	**8.34**	**7.79**	**18.66**	**57.17**	**28.64**	**34.05**	**15.11**	**162.4**	**9.8**	**31.34**	**8.33**
%Impervious	21.29992169	0	34.91655969	3.751339764	0.24488368	10.89385475	12.12922173	0	0	0	0	0

Land Use	**Acres**	**Hectares**	**Coefficient**	**Kg/ha/yr TP Load**
Beech/Oak	22.29	9.02	0.20	1.80
Cleared/Other	9.07	3.67	0.50	1.84
Hay/Rotation/Pasture	2.69	1.09	0.60	0.65
Hemlock	48.93	19.80	0.20	3.96
Mixed Forest	70.79	28.65	0.20	5.73
Open Water	20.33	8.23	0.00	0.00
Other Hardwoods	53.39	21.61	0.20	4.32
Paper Birch/Aspen	105.03	42.51	0.20	8.50
Spruce/Fir	0.77	0.31	0.20	0.06
Transportation	13.53	5.48	0.50	2.74
White/Red Pine	70.03	28.34	0.20	5.67
Wetland	3.33	1.35	0.05	0.07
Total				**35.34**

Month	**Precip (m)**	**%precip**	**Monthly Cont.**
Jun-00	0.061722	0.0899001	3.177162928
Jul-00	0.090932	0.1324454	4.680758553
Aug-00	0.083566	0.1217166	4.301590961
Sep-00	0.060198	0.0876804	3.098714461
Oct-00	0.057912	0.0843507	2.98104176
Nov-00	0.086614	0.1261561	4.458487896
Dec-00	0.05969	0.0869404	3.072564972
Jan-01	0.002286	0.0033296	0.117672701
Feb-01	0.054864	0.0799112	2.824144825
Mar-01	0.053594	0.0780614	2.758771102
Apr-01	0.02667	0.0388457	1.372848179
May-01	0.048514	0.0706622	2.497276211
	0.686562		35.34103455

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
1-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Jun	0.02	0.00051	213.60	213597.94	0.1000	21359.7937	0.0000
3-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Jun	0.43	0.01092	4592.36	4592355.65	0.1000	459235.5646	0.0005
7-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Jun	0.05	0.00127	533.99	533994.84	0.1000	53399.4843	0.0001
9-Jun	0.03	0.00076	320.40	320396.91	0.1000	32039.6906	0.0000
10-Jun	0.01	0.00025	106.80	106798.97	0.1000	10679.8969	0.0000
11-Jun	0.48	0.01219	5126.35	5126350.49	0.1000	512635.0489	0.0005
12-Jun	0.01	0.00025	106.80	106798.97	0.1000	10679.8969	0.0000
13-Jun	0.07	0.00178	747.59	747592.78	0.1000	74759.2780	0.0001
14-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
17-Jun	0.13	0.00330	1388.39	1388386.59	0.1000	138838.6591	0.0001
18-Jun	0.12	0.00305	1281.59	1281587.62	0.1000	128158.7622	0.0001
19-Jun	0.01	0.00025	106.80	106798.97	0.1000	10679.8969	0.0000
20-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Jun	0.02	0.00051	213.60	213597.94	0.1000	21359.7937	0.0000
22-Jun	0.11	0.00279	1174.79	1174788.65	0.1000	117478.8654	0.0001
23-Jun	0.02	0.00051	213.60	213597.94	0.1000	21359.7937	0.0000
24-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Jun	0.07	0.00178	747.59	747592.78	0.1000	74759.2780	0.0001
26-Jun	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Jun	0.33	0.00838	3524.37	3524365.96	0.1000	352436.5961	0.0004
28-Jun	0.01	0.00025	106.80	106798.97	0.1000	10679.8969	0.0000
29-Jun	0.22	0.00559	2349.58	2349577.31	0.1000	234957.7307	0.0002
30-Jun	0.29	0.00737	3097.17	3097170.09	0.1000	309717.0087	0.0003
Total	**2.43**	**0.06172**	**25952.14935**	**25952149.35**	**1.9000**	**2595214.935**	**0.002595215**
Mean	**0.081**	**0.00206**	**865.07165**	**865071.645**	**0.0633**	**86507.1645**	**8.65072E-05**
St Dev	**0.133658082**	**0.00339**	**1427.45452**	**1427454.524**	**0.0490**	**142745.4524**	**0.000142745**
1-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Jul	0.01	0.00025	106.80	106798.97	0.1000	10679.8969	0.0000
3-Jul	0.34	0.00864	3631.16	3631164.93	0.1000	363116.4930	0.0004
4-Jul	0.38	0.00965	4058.36	4058360.80	0.1000	405836.0804	0.0004
5-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Jul	0.02	0.00051	213.60	213597.94	0.1000	21359.7937	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
9-Jul	0.06	0.00152	640.79	640793.81	0.1000	64079.3811	0.0001
10-Jul	0.06	0.00152	640.79	640793.81	0.1000	64079.3811	0.0001
11-Jul	0.02	0.00051	213.60	213597.94	0.1000	21359.7937	0.0000
12-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Jul	0.27	0.00686	2883.57	2883572.15	0.1000	288357.2150	0.0003
15-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-Jul	0.47	0.01194	5019.55	5019551.52	0.1000	501955.1520	0.0005
17-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Jul	0.62	0.01575	6621.54	6621536.05	0.1300	860799.6863	0.0009
19-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Jul	0.03	0.00076	320.40	320396.91	0.1300	41651.5977	0.0000
21-Jul	0.02	0.00051	213.60	213597.94	0.1300	27767.7318	0.0000
22-Jul	0.38	0.00965	4058.36	4058360.80	0.1300	527586.9045	0.0005
23-Jul	0.01	0.00025	106.80	106798.97	0.1300	13883.8659	0.0000
24-Jul	0.01	0.00025	106.80	106798.97	0.1300	13883.8659	0.0000
25-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Jul	0.75	0.01905	8009.92	8009922.64	0.1300	1041289.9431	0.0010
29-Jul	0.1	0.00254	1067.99	1067989.69	0.1300	138838.6591	0.0001
30-Jul	0.03	0.00076	320.40	320396.91	0.1300	41651.5977	0.0000
31-Jul	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**3.58**	**0.09093**	**38234.03073**	**38234030.73**	**2.0700**	**4448177.039**	**0.004448177**
Mean	**0.115483871**	**0.00293**	**1233.35583**	**1233355.83**	**0.0668**	**143489.5819**	**0.00014349**
St Dev	**0.204301064**	**0.00519**	**2181.91429**	**2181914.29**	**0.0588**	**266467.5355**	**0.000266468**
1-Aug	0.01	0.00025	106.80	106798.97	0.1300	13883.8659	0.0000
2-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Aug	0.63	0.01600	6728.34	6728335.02	0.1300	874683.5522	0.0009
4-Aug	0.01	0.00025	106.80	106798.97	0.1300	13883.8659	0.0000
5-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Aug	0.04	0.00102	427.20	427195.87	0.1300	55535.4636	0.0001
7-Aug	0.48	0.01219	5126.35	5126350.49	0.0530	271696.5759	0.0003
8-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Aug	0.26	0.00660	2776.77	2776773.18	0.0530	147168.9786	0.0001
10-Aug	0.03	0.00076	320.40	320396.91	0.0530	16981.0360	0.0000
11-Aug	0.15	0.00381	1601.98	1601984.53	0.0530	84905.1800	0.0001
12-Aug	0.01	0.00025	106.80	106798.97	0.0530	5660.3453	0.0000
13-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Aug	0.9	0.02286	9611.91	9611907.17	0.0530	509431.0798	0.0005
15-Aug	0.01	0.00025	106.80	106798.97	0.0530	5660.3453	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
16-Aug	0.44	0.01118	4699.15	4699154.61	0.0440	206762.8031	0.0002
17-Aug	0.04	0.00102	427.20	427195.87	0.0440	18796.6185	0.0000
18-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
19-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
20-Aug	0.03	0.00076	320.40	320396.91	0.0440	14097.4638	0.0000
21-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
23-Aug	0.17	0.00432	1815.58	1815582.46	0.0440	79885.6285	0.0001
24-Aug	0.02	0.00051	213.60	213597.94	0.0440	9398.3092	0.0000
25-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
27-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
28-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
29-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Aug	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
31-Aug	0.01	0.00025	106.80	106798.97	0.0440	4699.1546	0.0000
Total	**3.29**	**0.08357**	**35136.86064**	**35136860.64308**	**1.3750**	**2356626.03936**	**0.00236**
Mean	**0.211935484**	**0.00538**	**2263.44911**	**2263449.10702**	**0.0845**	**151592.52299**	**0.00015**
St Dev	**0.609412786**	**0.01548**	**6508.46569**	**6508465.69047**	**0.2418**	**447153.53097**	**0.00045**
1-Sep	0.02	0.00051	213.60	213597.94	0.0400	8543.9175	0.0000
2-Sep	0.42	0.01067	4485.56	4485556.68	0.0400	179422.2671	0.0002
3-Sep	0.06	0.00152	640.79	640793.81	0.0400	25631.7524	0.0000
4-Sep	0.21	0.00533	2242.78	2242778.34	0.0400	89711.1336	0.0001
5-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
10-Sep	0.01	0.00025	106.80	106798.97	0.0400	4271.9587	0.0000
11-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-Sep	0.05	0.00127	533.99	533994.84	0.0400	21359.7937	0.0000
13-Sep	0.12	0.00305	1281.59	1281587.62	0.0400	51263.5049	0.0001
14-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Sep	0.96	0.02438	10252.70	10252700.98	0.0400	410108.0391	0.0004
16-Sep	0.05	0.00127	533.99	533994.84	0.0400	21359.7937	0.0000
17-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Sep	0.01	0.00025	106.80	106798.97	0.0400	4271.9587	0.0000
19-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Sep	0.2	0.00508	2135.98	2135979.37	0.0400	85439.1748	0.0001
21-Sep	0.1	0.00254	1067.99	1067989.69	0.0400	42719.5874	0.0000
22-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
23-Sep	0.11	0.00279	1174.79	1174788.65	0.0400	46991.5461	0.0000
24-Sep	0.05	0.00127	533.99	533994.84	0.0400	21359.7937	0.0000
25-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
29-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Sep	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**2.37**	**0.06020**	**25311.35554**	**25311355.53924**	**0.5600**	**1012454.22157**	**0.00101**
Mean	**0.079**	**0.00201**	**843.71185**	**843711.85131**	**0.0187**	**33748.47405**	**0.00003**
St Dev	**0.189652132**	**0.00482**	**2025.46520**	**2025465.20365**	**0.0203**	**81018.60815**	**0.00008**
1-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Oct	0.14	0.00356	1495.19	1495185.56	0.0440	65788.1646	0.0001
5-Oct	0.49	0.01245	5233.15	5233149.46	0.0440	230258.5761	0.0002
6-Oct	0.28	0.00711	2990.37	2990371.12	0.0440	131576.3292	0.0001
7-Oct	0.08	0.00203	854.39	854391.75	0.0440	37593.2369	0.0000
8-Oct	0.22	0.00559	2349.58	2349577.31	0.0440	103381.4015	0.0001
9-Oct	0.03	0.00076	320.40	320396.91	0.0440	14097.4638	0.0000
10-Oct	0.07	0.00178	747.59	747592.78	0.0440	32894.0823	0.0000
11-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-Oct	0.11	0.00279	1174.79	1174788.65	0.0440	51690.7008	0.0001
17-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Oct	0.46	0.01168	4912.75	4912752.55	0.0110	54040.2781	0.0001
19-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
23-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
24-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Oct	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Oct	0.01	0.00025	106.80	106798.97	0.0110	1174.7887	0.0000
28-Oct	0.01	0.00025	106.80	106798.97	0.0110	1174.7887	0.0000
29-Oct	0.13	0.00330	1388.39	1388386.59	0.0110	15272.2525	0.0000
30-Oct	0.24	0.00610	2563.18	2563175.24	0.0110	28194.9277	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
31-Oct	0.01	0.00025	106.80	106798.97	0.0110	1174.7887	0.0000
Total	**2.28**	**0.05791**	**24350.16482**	**24350164.82256**	**0.4180**	**768311.77953**	**0.00077**
Mean	**0.073548387**	**0.00187**	**785.48919**	**785489.18782**	**0.0135**	**24784.25095**	**0.00002**
St Dev	**0.132854517**	**0.00337**	**1418.87253**	**1418872.53360**	**0.0188**	**50207.48083**	**0.00005**
1-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Nov	0.04	0.00102	427.20	427195.87	0.0110	4699.1546	0.0000
4-Nov	0.04	0.00102	427.20	427195.87	0.0110	4699.1546	0.0000
5-Nov	0.77	0.01956	8223.52	8223520.58	0.0110	90458.7263	0.0001
6-Nov	0.06	0.00152	640.79	640793.81	0.0110	7048.7319	0.0000
7-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Nov	0.01	0.00025	106.80	106798.97	0.0110	1174.7887	0.0000
10-Nov	0.66	0.01676	7048.73	7048731.92	0.0110	77536.0511	0.0001
11-Nov	0.29	0.00737	3097.17	3097170.09	0.0110	34068.8710	0.0000
12-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Nov	0.57	0.01448	6087.54	6087541.21	0.0060	36525.2472	0.0000
15-Nov	0.22	0.00559	2349.58	2349577.31	0.0080	18796.6185	0.0000
16-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
17-Nov	0.04	0.00102	427.20	427195.87	0.0080	3417.5670	0.0000
18-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
19-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Nov	0.05	0.00127	533.99	533994.84	0.0080	4271.9587	0.0000
22-Nov	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
23-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
24-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Nov	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Nov	0.35	0.00889	3737.96	3737963.90	0.0080	29903.7112	0.0000
27-Nov	0.21	0.00533	2242.78	2242778.34	0.0055	12335.2809	0.0000
28-Nov	0.05	0.00127	533.99	533994.84	0.0055	2936.9716	0.0000
29-Nov	0.03	0.00076	320.40	320396.91	0.0055	1762.1830	0.0000
30-Nov	0.01	0.00025	106.80	106798.97	0.0055	587.3943	0.0000
Total	**3.41**	**0.08661**	**36418.44827**	**36418448.26532**	**0.1450**	**331076.80241**	**0.00033**
Mean	**0.113666667**	**0.00289**	**1213.94828**	**1213948.27551**	**0.0048**	**11035.89341**	**0.00001**
St Dev	**0.210048982**	**0.00534**	**2243.30146**	**2243301.45841**	**0.0046**	**22417.15943**	**0.00002**
1-Dec	0.01	0.00025	106.80	106798.97	0.0055	587.3943	0.0000
2-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
3-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
10-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
11-Dec	0.01	0.00025	106.80	106798.97	0.0055	587.3943	0.0000
12-Dec	0.22	0.00559	2349.58	2349577.31	0.0055	12922.6752	0.0000
13-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Dec	0.19	0.00483	2029.18	2029180.40	0.0055	11160.4922	0.0000
16-Dec	0.19	0.00483	2029.18	2029180.40	0.0055	11160.4922	0.0000
17-Dec	1.68	0.04267	17942.23	17942226.71	0.0050	89711.1336	0.0001
18-Dec	0.01	0.00025	106.80	106798.97	0.0050	533.9948	0.0000
19-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-Dec	0.04	0.00102	427.20	427195.87	0.0160	6835.1340	0.0000
23-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
24-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
29-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
31-Dec	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**2.35**	**0.05969**	**25097.75760**	**25097757.60220**	**0.05350**	133498.71065	0.00013
Mean	**0.075806452**	**0.00193**	**809.60508**	**809605.08394**	**0.00173**	**4306.41002**	**0.00000**
St Dev	**0.303685958**	**0.00771**	**3243.33471**	**3243334.71043**	**0.00349**	**16265.49546**	**0.00002**
1-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Jan	0.02	0.00051	213.60	213597.94	0.0120	2563.1752	0.0000
6-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Jan	0.01	0.00025	106.80	106798.97	0.0120	1281.5876	0.0000
9-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
10-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
11-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-Jan	0.01	0.00025	106.80	106798.97	0.0120	1281.5876	0.0000
17-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
19-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
23-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
24-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Jan	0.04	0.00102	427.20	427195.87	0.0120	5126.3505	0.0000
27-Jan	0.01	0.00025	106.80	106798.97	0.0120	1281.5876	0.0000
28-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
29-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
31-Jan	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**0.09**	**0.00229**	**961.19072**	**961190.71668**	**0.0600**	**11534.28860**	**0.00001**
Mean	**0.002903226**	**0.00007**	**31.00615**	**31006.15215**	**0.0019**	**372.07383**	**0.00000**
St Dev	**0.008243603**	**0.00021**	**88.04083**	**88040.82897**	**0.0045**	**1056.48995**	**0.00000**
1-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
10-Feb	1.75	0.04445	18689.82	18689819.49	0.0050	93449.0975	0.0001
11-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Feb	0.06	0.00152	640.79	640793.81	0.0050	3203.9691	0.0000
16-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
17-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
19-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Feb	0.03	0.00076	320.40	320396.91	0.0050	1601.9845	0.0000
21-Feb	0.01	0.00025	106.80	106798.97	0.0050	533.9948	0.0000
22-Feb	0.01	0.00025	106.80	106798.97	0.0050	533.9948	0.0000
23-Feb	0.1	0.00254	1067.99	1067989.69	0.0085	9077.9123	0.0000
24-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Feb	0.19	0.00483	2029.18	2029180.40	0.0085	17248.0334	0.0000
26-Feb	0.01	0.00025	106.80	106798.97	0.0085	907.7912	0.0000
27-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Feb	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**2.16**	**0.05486**	**23068.57720**	**23068577.20032**	**0.0505**	**126556.77770**	**0.00013**
Mean	**0.077142857**	**0.00196**	**823.87776**	**823877.75715**	**0.0018**	**4519.88492**	**0.00000**
St Dev	**0.330362956**	**0.00839**	**3528.24229**	**3528242.29126**	**0.0030**	**17800.16755**	**0.00002**
1-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-Mar	0.01	0.00025	106.80	106798.97	0.0085	907.7912	0.0000
3-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Mar	0.18	0.00457	1922.38	1922381.43	0.0110	21146.1958	0.0000
6-Mar	0.28	0.00711	2990.37	2990371.12	0.0110	32894.0823	0.0000
7-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-Mar	0.12	0.00305	1281.59	1281587.62	0.0110	14097.4638	0.0000
10-Mar	0.01	0.00025	106.80	106798.97	0.0110	1174.7887	0.0000
11-Mar	0.07	0.00178	747.59	747592.78	0.0110	8223.5206	0.0000
12-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
13-Mar	0.23	0.00584	2456.38	2456376.28	0.0120	29476.5153	0.0000
14-Mar	0.07	0.00178	747.59	747592.78	0.0120	8971.1134	0.0000
15-Mar	0.01	0.00025	106.80	106798.97	0.0120	1281.5876	0.0000
16-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
17-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
19-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-Mar	0.56	0.01422	5980.74	5980742.24	0.0120	71768.9068	0.0001
23-Mar	0.16	0.00406	1708.78	1708783.50	0.0120	20505.4020	0.0000
24-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
27-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Mar	0.03	0.00076	320.40	320396.91	0.0120	3844.7629	0.0000
29-Mar	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Mar	0.08	0.00203	854.39	854391.75	0.0080	6835.1340	0.0000
31-Mar	0.3	0.00762	3203.97	3203969.06	0.0080	25631.7524	0.0000
Total	**2.11**	**0.05359**	**22534.58236**	**22534582.35772**	**0.1515**	**246759.01677**	**0.00025**
Mean	**0.068064516**	**0.00173**	**726.92201**	**726922.01154**	**0.0049**	**7959.96828**	**0.00001**
St Dev	**0.126633838**	**0.00322**	**1352.43633**	**1352436.33227**	**0.0056**	**15356.08574**	**0.00002**
1-Apr	0.03	0.00076	320.40	320396.91	0.0080	2563.1752	0.0000
2-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
3-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
6-Apr	0.11	0.00279	1174.79	1174788.65	0.0080	9398.3092	0.0000
7-Apr	0.02	0.00051	213.60	213597.94	0.0080	1708.7835	0.0000
8-Apr	0.33	0.00838	3524.37	3524365.96	0.0080	28194.9277	0.0000
9-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
10-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
11-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-Apr	0.32	0.00813	3417.57	3417566.99	0.0080	27340.5359	0.0000
13-Apr	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
14-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
17-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
18-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
19-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
20-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-Apr	0.04	0.00102	427.20	427195.87	0.0080	3417.5670	0.0000
22-Apr	0.11	0.00279	1174.79	1174788.65	0.0080	9398.3092	0.0000
23-Apr	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
24-Apr	0.07	0.00178	747.59	747592.78	0.0080	5980.7422	0.0000
25-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
26-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
27-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
28-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
29-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
30-Apr	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**1.05**	**0.02667**	**11213.89169**	**11213891.69460**	**0.0800**	**89711.13356**	**0.00009**
Mean	**0.035**	**0.00089**	**373.79639**	**373796.38982**	**0.0027**	**2990.37112**	**0.00000**

Day	Precip (in)	Precip (m)	Direct Lake Precip (m3)	Precip to Lake (L)	TP mg/L	Direct Lake TP (mg)	Kg P to lake
St Dev	**0.084435243**	**0.00214**	**901.75969**	**901759.69125**	**0.0038**	**7214.07753**	**0.00001**
1-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
2-May	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
3-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
4-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
5-May	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
6-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
7-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
8-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
9-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
10-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
11-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
12-May	0.75	0.01905	8009.92	8009922.64	0.0080	64079.3811	0.0001
13-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
14-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
15-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
16-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
17-May	0.02	0.00051	213.60	213597.94	0.0080	1708.7835	0.0000
18-May	0.14	0.00356	1495.19	1495185.56	0.0080	11961.4845	0.0000
19-May	0.02	0.00051	213.60	213597.94	0.0080	1708.7835	0.0000
20-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
21-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
22-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
23-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
24-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
25-May	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
26-May	0.29	0.00737	3097.17	3097170.09	0.0080	24777.3607	0.0000
27-May	0.52	0.01321	5553.55	5553546.36	0.0080	44428.3709	0.0000
28-May	0.08	0.00203	854.39	854391.75	0.0080	6835.1340	0.0000
29-May	0.05	0.00127	533.99	533994.84	0.0080	4271.9587	0.0000
30-May	0.01	0.00025	106.80	106798.97	0.0080	854.3917	0.0000
31-May	0	0.00000	0.00	0.00	0.0000	0.0000	0.0000
Total	**1.91**	**0.04851**	**20398.60299**	**20398602.98732**	**0.0960**	**163188.82390**	**0.00016**
Mean	**0.061612903**	**0.00156**	**658.01945**	**658019.45120**	**0.0031**	**5264.15561**	**0.00001**
St Dev	**0.166234709**	**0.00422**	**1775.36955**	**1775369.54593**	**0.0040**	**14202.95637**	**0.00001**
Lake Area	420468.38	m2					

TP Calculation based on hydrologic budget for seepage and mean monthly seepage TP conc.

Month	*Precip (m)*	*Seepage (103m3/mo)*	*L/mo*	*mean ug/L*	*ug/mo*	*kg/mo*
June	0.06	36.41054808	36410548	48	1747706308	1.747706
July	0.09	33.3580249	33358025	48	1601185195	1.601185
August	0.08	28.44829823	28448298	48	1365518315	1.365518
September	0.06	37.70714925	37707149	48	1809943164	1.809943
October	0.06	33	33000000	48	1584000000	1.584
November	0.09	33	33000000	48	1584000000	1.584
December	0.06	33	33000000	48	1584000000	1.584
January	0.00	40.29	40290000	48	1933920000	1.93392
February	0.05	59	59000000	48	2832000000	2.832
March	0.05	62.31	62310000	48	2990880000	2.99088
April	0.03	33	33000000	48	1584000000	1.584
May	0.05	56.32	56320000	48	2703360000	2.70336

Appendix Three

Septic System Survey

Sewage Disposal System Survey

1. What type of sewage disposal system do you have on your property?

Septic Tank/Leach Field Cesspool Holding Tank Chemical Toilet Outhouse

2. How old is your disposal system (in years)?

1-10 10-15 15-20 20-25 I don't know

3. At least how many feet from the shore of the lake is your septic system located?

10-20 20-50 50-75 Greater than 75 feet

4. Are you a year round resident or seasonal?

Year round Seasonal

5. If you are a seasonal resident, how many months out of the year do you spend in your lake home?

____

6. In what condition is your septic system?

Good Moderate Poor I don't know

7. Do you have any problems with your septic system (odors, surface discharge, clogging)?

Yes No

8. Have you made any repairs on your septic system?

Yes No

9. How often do you have your septic tank pumped?

Every 1-3 years Every 3-5 years Every 10 years Never

10. What size lot do you own?

1/4 acre 1/2 acre 1 acre >1 acre

11. How far away from the lake edge is your home located?

10-20 feet   20-50 feet   50-75 feet   >75 feet

12. What is your drinking water source?

Dug Well   Drilled Well   Public Water   Bottled Water   I don't know

13. How many bedrooms does your home/cottage have?

1   2   3   More than 3

14. How many people typically occupy your lot?

1   2   3   4   5   >5

15. Which of the following water-using machines do you have on your lakefront dwelling?

Washing Machine   Garbage Disposal   Dishwasher   Water Softener

Other_______________________________

16. Location Information:

Your Name:
Lake Address:
Lot #:
Phone Number:

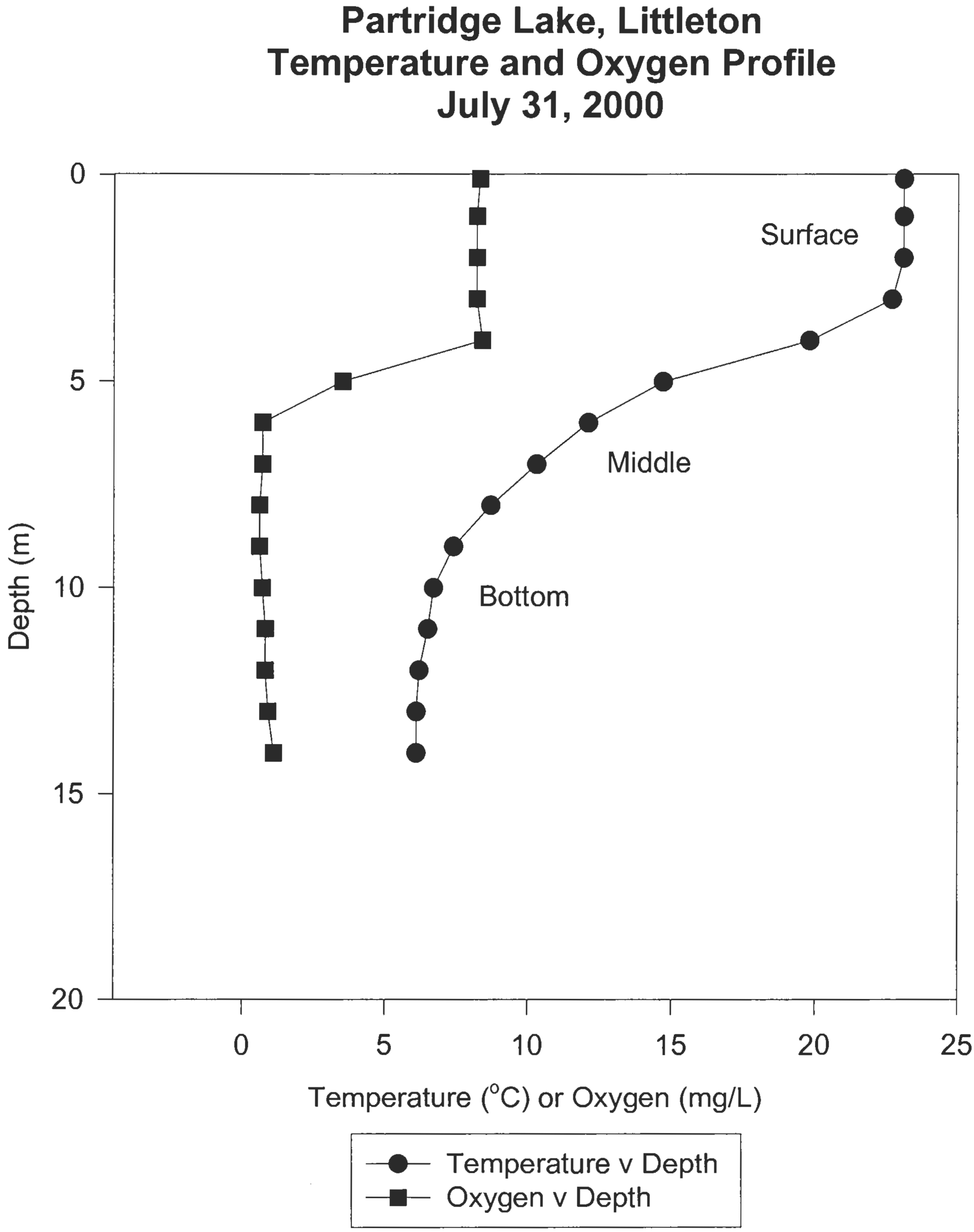
Comments (optional):

When form is complete, please mail to:
Amy P. Smagula
NH Department of Environmental Services
PO Box 95
6 Hazen Drive
Concord, NH 03302-0095
or fax to (603)271-7894

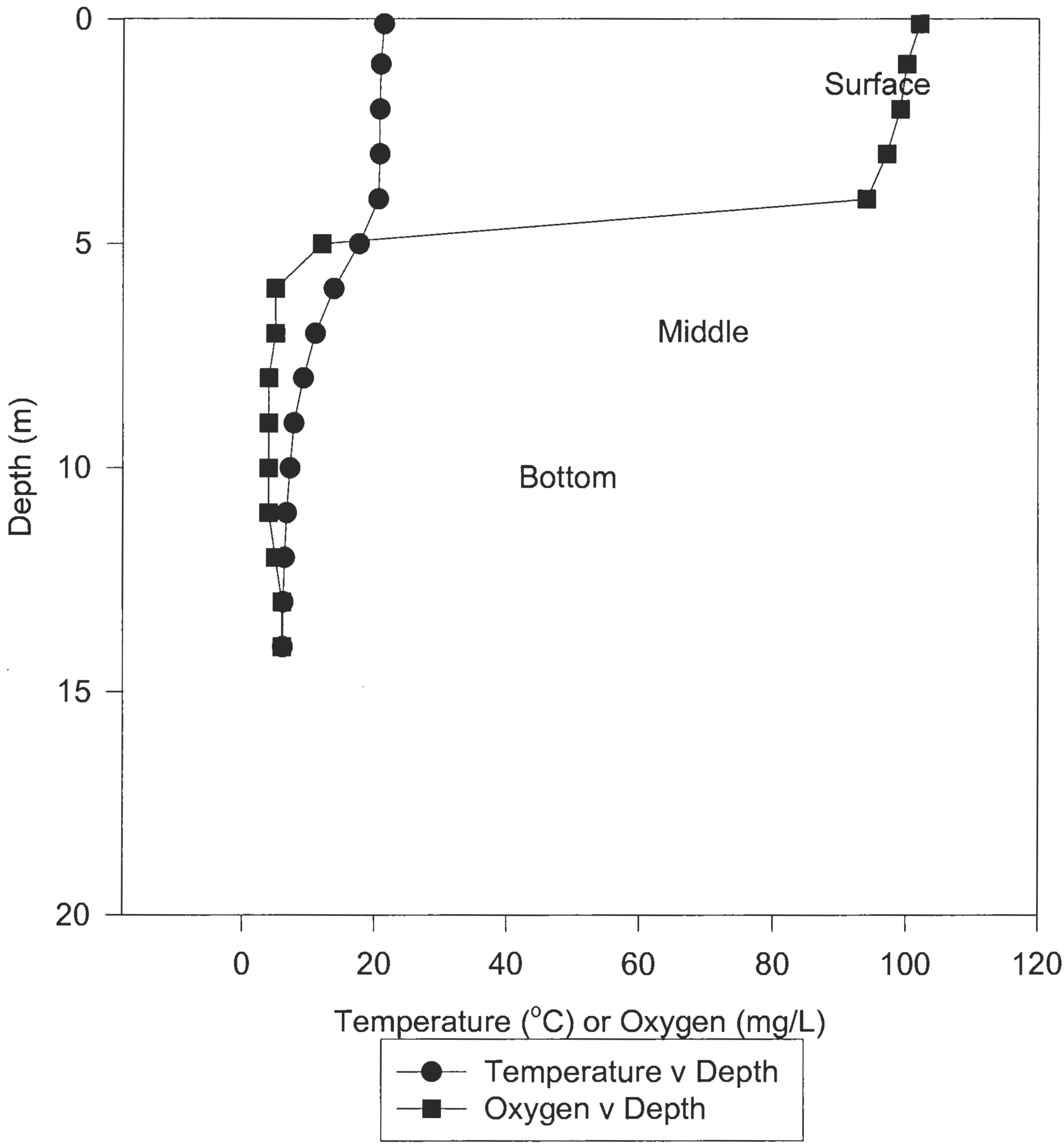
For more information, I can be reached at (603)271-2248 or asmagula@des.state.nh.us

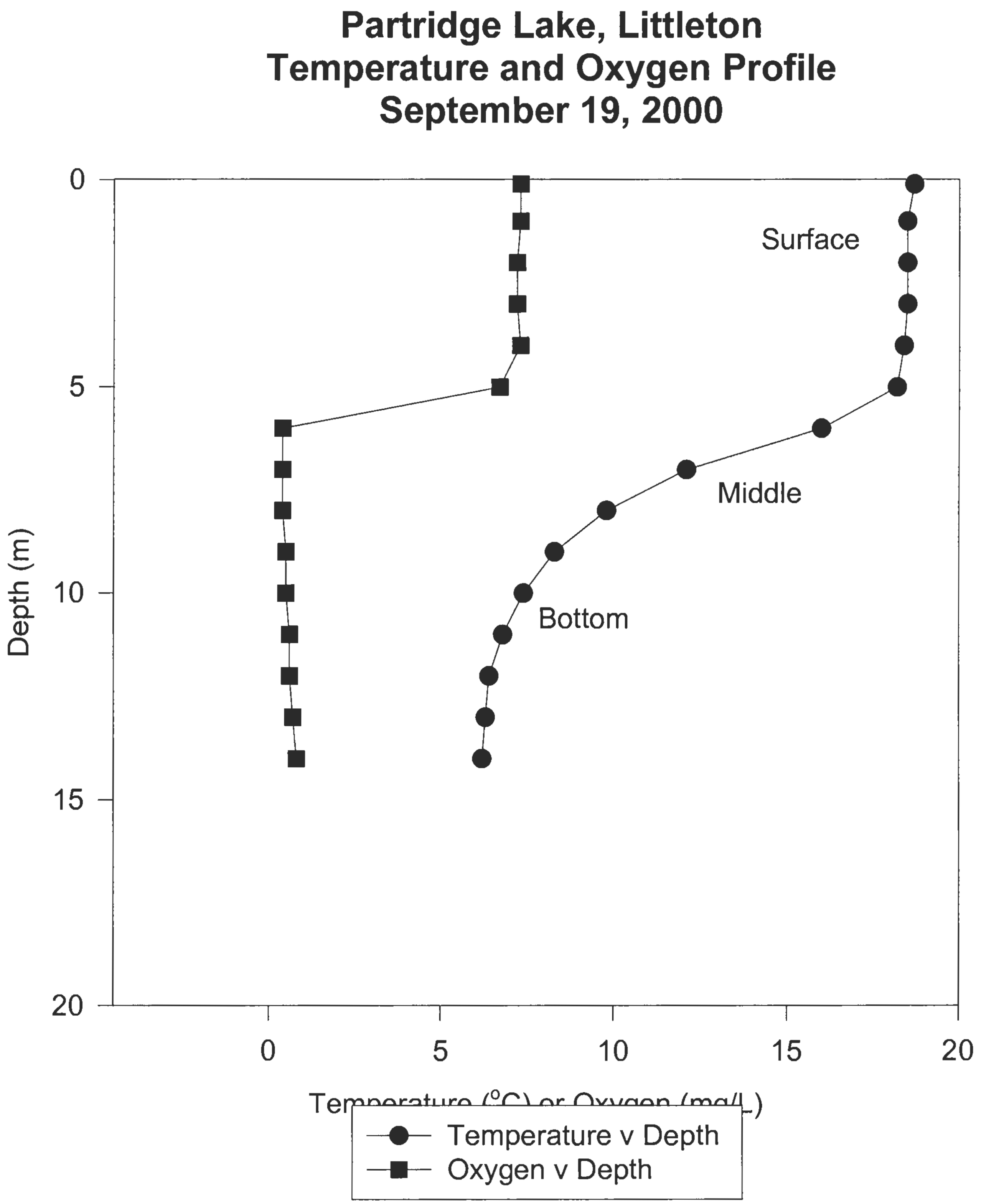
Appendix Four

Temperature and Oxygen Graphs


Partridge Lake, Littleton
Temperature and Oxygen Profile
July 31, 2000
Surface
Middle
Bottom
Depth (m)
0
5
10
15
20
0
5
10
15
20
25
Temperature (°C) or Oxygen (mg/L)
Temperature v Depth
Oxygen v Depth

Partridge Lake, Littleton
Temperature and Oxygen Profile
August 21, 2000





Partridge Lake, Littleton
Temperature and Oxygen Profile
September 19, 2000
Surface
Middle
Bottom
Depth (m)
0
5
10
15
20
0
5
10
15
20
Temperature v Depth
Oxygen v Depth

Appendix Five

In-Lake and Tributary Raw Data

Partridge Lake: In-Lake Raw Data

Station	Date	pH	ANC	Conductivity	Turbidity	Chlorophyll-a	Secchi Depth
Epilimnion 2M	7/31/2000	7.45	21.60	76.84	0.39	3.86	5.40
Epilimnion	8/21/2000	7.33	22.70	76.65	0.46	4.74	5.21
Epilimnion 3M	9/19/2000	7.22	22.90	78.14	0.48	4.74	
Mean		**7.33**	**22.40**	**77.21**	**0.44**	**4.45**	**5.31**
Median		**7.33**	**22.70**	**76.84**	**0.46**	**4.74**	**5.31**
Standard Deviation		**0.12**	**0.70**	**0.81**	**0.05**	**0.51**	**0.13**
Hypolimnion 12M	7/31/2000	6.57		93.38	0.75		
Hypolimnion	8/21/2000	6.60		92.06	2.70		
Hypolimnion 12M	9/19/2000	6.60		101.10	4.20		
Mean		**6.59**		**95.51**	**2.55**		
Median		**6.60**		**93.38**	**2.70**		
Standard Deviation		**0.02**		**4.88**	**1.73**		
Metalimnion 7M	7/31/2000	6.56		85.35	0.45		
Metalimnion	8/21/2000	6.57		86.26	0.53		
Metalimnion 7M	9/19/2000	6.60		89.60	0.56		
Mean		**6.58**		**87.07**	**0.51**		
Median		**6.57**		**86.26**	**0.53**		
Standard Deviation		**0.02**		**2.24**	**0.06**		

Mean Tributary Chemistry Data

Station	Sample #	Mean pH[1]	Median	St. Dev.	Mean Turb (NTU)	Median	St. Dev.	Mean Conductivity (umhos/cm)	Median	St. Dev.	Mean TP (ug/L)	Median	St. Dev.
A	n=11	7.17	7.19	N/A	0.27	0.27	0.46	83.26	93.52	33.99	7	7	2
D	n=3	6.96	6.95	N/A	0.25	0.26	0.06	69.41	73.88	14.46	7	7	
E	n=5	7.20	7.16	N/A	3.01	0.22	5.87	100.91	103.10	6.99	43	42	50
F	n=7	6.76	6.71	N/A	1.04	0.26	1.94	45.01	48.05	6.35	19	17	16
G	n=11	7.35	7.43	N/A	0.39	0.26	0.44	153.46	163.05	21.79	15	12	6
H	n=11	7.28	7.35	N/A	0.35	0.33	0.19	95.98	94.14	17.80	9	8	6
J	n=10	7.21	7.20	N/A	0.46	0.37	0.31	76.99	83.76	31.21	13	8	13
K	n=2	7.29	7.31	N/A	0.31	0.31	0.06	55.41	N/A	17.17	no data		
L	n=4	6.42	6.39	N/A	1.63	0.82	1.79	72.53	75.08	15.05	18	18	15
Outlet	n=12	7.15	7.25	N/A	0.42	0.46	0.13	78.00	76.86	8.52	14	10	12

1- True mean pH

Appendix Six

Best Management Practice- Options and Summaries

The following is a select list of stormwater management (BMPs) for New Hampshire (RCCD, 1992):

- ***Detention and Retention Basins*** control the runoff from a given storm event and release the excess runoff in a way to reduce the impact on downstream systems. The basin releases the temporarily stored runoff over an extended period of time at a rate equal to or less than the pre-development conditions. The existing stream system will experience no greater flooding than would have occurred before development took place. However, longer duration flows may cause some stream degradation. It should be understood that detention and retention basins generally do not decrease the volume of runoff, but do decrease the rate of runoff. This practice applies to sites where the physical conditions are conducive to constructing an embankment, emergency spillway, a storage area and a structural outlet system.
- ***Diversions*** intercept and divert water from areas where it is in excess to sites where it can be used or disposed of safely.

  Diversions are used to:

  - Divert runoff from highly erodible areas where the runoff is damaging property, causing erosion, or interfering with the establishment of vegetation;
  - Divert surface flow and subsurface flow away from steeply sloping land;

- ***Stone lined infiltration trenches*** provide temporary storage of runoff in the void spaces around the stone and allows the stored runoff to infiltrate into the surrounding soil. This practice applies to sites where the soils are sufficiently permeable to provide a reasonable rate of infiltration. The water table and bedrock must be lower than the design depth of the trench. This practice is not recommended where runoff water contains a high percentage of suspended materials, oils and greases unless measures are taken to remove them before they reach the trench.
- An ***extended detention dry basin*** is used to reduce peak discharges from a given storm event by controlling the release rate and to improve water quality by removing pollutants from runoff. This practice applies to sites where the physical conditions are conducive to constructing an embankment, emergency spillway, a storage area, and a designed outlet system.
- A ***dry well*** is similar to an infiltration trench. It provides temporary storage of runoff in the constructed chamber and/or in the void spaces in the aggregate, and allows the stored runoff to infiltrate into the soil. This practice applies to sites where the soils are sufficiently permeable to provide a reasonable rate of infiltration. Both the water table and bedrock must be lower than the design depth of the well. This practice is not recommended where runoff water contains high concentrations of sediment, oils, greases, and floatable organic materials unless measures are taken to remove them before they reach the well. Dry wells are generally used to store runoff from roof top areas; however, they can be used to provide storage and infiltration from catch basins where conditions permit.
- A ***level spreader*** changes concentrated flow into sheet flow and then outlets it onto stable areas without causing erosion. An example would be at the outlet of a diversion or a waterway. The level spreader is used where it can be constructed on undisturbed soils, where the area directly below the spreader is stabilized by existing vegetation, where the water will not re-concentrate immediately below the spreader, and where there is at least 100 feet of vegetated area between the spreader and surface water.
- ***Rock riprap*** protects soil from erosion due to concentrated runoff. It is used to stabilize slopes that are unstable due to seepage. It is also used to slow the velocity of concentrated runoff which in turn increases the potential for infiltration. Rock riprap can

be used at the outlets of pipes and constructed channels where the velocity of flow from these structures exceeds the capacity of the downstream area to resist erosion. Rock riprap can be used for wave protection on lakeshores and beaches. The practice can be used for storm drain outlets, in channels, in roadside ditches, on unstable slopes, at the top of slopes, and for drop structures.

- A ***vegetated filter strip*** improves water quality by removing sediment, nutrients, and other pollutants from runoff as it flows through the filter strip. Some of the sediment and pollutants are removed by filtering, absorption, adsorption and settling as the velocity of flow is reduced. This practice applies to any site where adequate vegetation can be established and maintained. Vegetative filter strips can be used effectively:
    1. Surrounding stormwater management infiltration practices to reduce the sediment load delivered to the structures;
    2. Adjacent to all water courses such as waterways and diversions and water bodies such as streams, ponds, and lakes;
    3. At the outlets of stormwater management structures; or
    4. Along the top of and at the base of slopes.
- ***Vegetated swales*** improve water quality by treating and removing pollutants from stormwater runoff, increasing infiltration, and reducing potential erosion from the discharge of runoff. This practice applies to all sites where a dense stand of vegetation can be established and where either a stable outlet exists or can be constructed as a suitable conveyance system to safely dispose of the runoff flowing from the swale. The swale can be used by itself or in combination with other stormwater management and/or erosion and sediment control practices to achieve the water quality improvement or flood peak reduction desired.

Shoreland Protection

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

SP-1 1998

Erosion Control for Construction in the Protected Shoreland Buffer Zone

EROSION IS A SERIOUS PROBLEM

Erosion is the process by which soil is carried by water or wind. When water carries soil into a waterbody, it not only fills in the waterbody but contributes nutrients that algae and aquatic weeds need to grow. When vegetation is removed or ground is disturbed, erosion accelerates, overloading the waterbody with nutrients and sediment. This can often contribute to excessive algae and aquatic weed growth, reducing the clarity and quality of the water.

Erosion at construction sites is a leading cause of water quality problems in New Hampshire waterbodies. Soils become vulnerable to erosion when construction activity removes or disturbs vegetative cover. These vegetative covers shield soil surface from the impact of rain, reduce the velocity of runoff, maintain the soil's capacity to absorb water, and hold soil particles in place. By limiting and phasing vegetation removal during construction, soil erosion can be significantly reduced.

The New Hampshire Comprehensive Shoreland Protection Act (CSPA) was passed to protect New Hampshire's lakes, ponds, rivers, and estuaries. The CSPA requires that any excavation or earth moving in protected shoreland must have appropriate erosion and sedimentation controls in accordence with the Alteration of Terrain Program (RSA 485-A:17 and Env-Ws 415). This fact sheet explains some methods to limit erosion during construction within the protected shoreland.

Problems caused by sediment include:

Lower Property Values: Property values may decline when a lake, pond or stream fills with sediment. Shallow areas encourage weed growth and create boating hazards.

Poor Fishing: Muddy water drives away fish like chain pickerel that rely on sight to feed. As it settles, sediment smothers gravel beds where fish like smallmouth bass find food and lay their eggs.

Nuisance Growth of Weeds and Algae: Sediment carries nutrients that feed algae and aquatic weeds.

Loss of Tourism: Shallow, mucky lakes, ponds and streams are not attractive to tourists or local residents.

Local Tax Impacts: Cleaning up sediment in streets, sewers and ditches adds extra costs to local government budgets.

PREVENTING EROSION IS EASY

Erosion control is important to protect the quality of New Hampshire's public waters. The materials needed are easy to find and are relatively inexpensive: hay bales or silt fence, stakes, mulch, gravel, and grass seed.

Putting these materials to use is a straight forward process. Only a few controls are needed on most sites.

Silt Fence or Hay Bales: These are used to trap sediment on the down slope side of the lot. Proper installation is the key to success.

Hay/Straw Mulch: This is used to cover disturbed soil and prevent erosion, promotes seed growth.

Temporary Diversions: These structures route clean water from up slope areas around the site.

Soil Pile Location: Locate erodable materials away from any roads or waterways.

Gravel Drive: Use gravel to limit the tracking of mud onto streets. Use of geotextiles under gravel stops pumping of gravel into underlying sediment and saves on maintenance.

Cleanup: Reclaim sediments that are carried off site by vehicles or storms.

Downspout Extenders: These prevent erosion from roof runoff and safe outlets to prevent scour. Vegetation, stone basins, and level spreaders are useful in outlet protection.

Vegitation: Preserving existing trees and vegetation where possible to prevent erosion.

Revegetation: Replant and seed sites as soon as possible with natural or native species. Do not underestimate the success of frost seeding and mulch as an alternative to leaving a slope bare until spring planting season.

HAY BALE OR SILT FENCE

Put up before any other work is done.

Install on down slope side(s) of site with ends extended up side slopes a short distance.

Place parallel to the contour of the land to allow water to pond behind the fence.

Entrench 4 inches deep (see back page). Stake (2 stakes per hay bale or 1 stake every 3 feet for silt fence).

Leave no gaps between hay bales or sections of silt fence.

Inspect and repair once a week and after every ½ inch rain. Remove sediment if deposits reach half the fence height.

Maintain until lawn is established or soil is stable.

HAY/STRAW MULCH

Place sufficient amount on disturbed soils as soon as possible so that surface of soil is not visible.

On small areas hold mulch by wetting, stakes, or string.

Required for seeding outside normal seeding season.

TEMPORARY DIVERSION OF RUNOFF

Install diversion upslope of disturbed areas where runoff is coming onto property from upslope areas.

Should be 1 to 2 feet deep with 1 foot bottom width and 3:1 side slope.

Do not use to intercept intermittent or perennial streams or dam wetland areas.

Stabilize with erosion control matting prior to use.

Install diversions that divert runoff into vegetated areas.

SOIL PILES

Locate away from steep slopes, any downslope street, driveway, stream, lake, wetland, ditch, or drainage way.

Temporary mulch seed such as annual rye, oats, or winter (cereal rye) is recommended for topsoil piles.

Slash piles are not allowed within 50 feet of the reference line of any waterbody.

GRAVEL DRIVE

Install a single access drive using 2 to 3 inch aggregate.

Lay gravel 6 inches deep and 7 feet wide from the foundation to the street (or 50 feet if less).

Use to prevent tracking dirt onto the road by all vehicles.

Maintain throughout construction.

SEDIMENT CLEANUP

By the end of each work day or after a storm, sweep or scrape up soil tracked onto the road or use a gravel buffer strip between construction site and paved road.

DOWNSPOUT EXTENDERS

Ground gutters (lined outlets on the ground under the dripeaves) work well also.

Highly recommended for sites with steep slopes.

The key to either system is an adequately protected outlet.

Install as soon as gutters and downspouts are completed.

Route water to a vegetated area.

Maintain until lawn is established or soil is stable.

REVEGETATION

Seed, sod or mulch bare soil as soon as possible.

Replant with native or naturalized species.

If using light mulch (prone to wind movement), use a tuckifier or krimp by tracking with a bulldozer to keep mulch in place.

Erosion control blankets, although more costly, are extremely effective and can be purchased already impregnated with seed.

SEEDING AND MULCHING

Spread 6 inches of topsoil.

Fertilizer cannot be used within 25 feet of public waters. Plant a buffer that does not require fertilizers.

Twenty-five feet beyond the reference line, low phosphate, slow release nitrogen fertilizer or limestone, may be used on lawns or areas with grass.

TIMING IS CRUCIAL

Fertilization should not be done until vegetation has germinated. If site is fertilized in winter and planted in spring, all value of fertilizer will have leached by the time of planting.

Seed with an appropriate mix for the site (see table).

Rake lightly to cover seed with 1/4" of soil. Roll lightly.

Mulch with hay or straw (70-90 lb. or one bale per 1000 sq. ft.).Tack mulch if prone to wind erosion.

Anchor mulch by punching 2 inches into the soil with a dull, weighted disk or by using netting or other measures on steep slopes.

Water gently every day or two to keep soil moist. Less watering is needed once grass is 2 inches tall. (This is when fertilizer should be applied.)

SODDING

Spread 6 inches of topsoil and lightly water the soil.

Lay sod. Tamp or roll lightly.

On slopes, lay sod starting at the bottom and work toward the top. Peg each piece down in several places.

Initial watering should wet soil 6 inches deep (or until water stands 1 inch deep in a straight-sided container). Then water lightly every day or two for 2 weeks.

If construction is completed after September 15, seeding or sodding may be delayed. Applying mulch or temporary seed (such as rye or winter rye) is recommended if weather permits. Hay bales or silt fences must be maintained until final seeding or sodding is completed in the spring (by June 1) or until all soils are stable.

PRESERVING EXISTING VEGETATION

Wherever possible, preserve existing trees, shrubs, and other vegetation.

To prevent root damage, do not grade, place soil piles, or park vehicles near trees marked for preservation.

Use top diameter of canopy as guideline to root width.

Under the Shoreland Protection Act, stumps cannot be removed within 50 feet of the reference line.

Place plastic mesh or snow fence barriers around trees to protect the trees and the area directly below their branches-using canopy diameter as the guideline for distance from the trunk needing protection.

Seed	Seeding Rates (Lbs./1000sq.ft.)	Seeding Rates (Lbs/Ac.)	Recommended Seeding Dates
Winter Rye	2.6	112(2.0bu)	8/15-10/1 (FALL)
Oats	2	80(2.5bu)	4/1-7/1 8/15-9/15
Annual Ryegrass	1	40(1.0bu)	4/1-6/1
Perennial Ryegrass	0.7	30(1.5bu)	4/1-6/1 8/15-9/15

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May 1997

Shoreland Protection
Outreach and Information (603) 271-7109

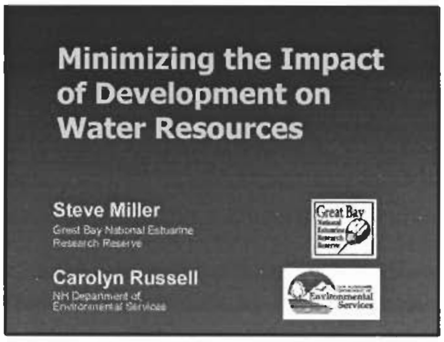
Compliance and Enforcement (603) 271-6876
NH Wetlands Bureau (603) 271-2147

Text-only for Print

Appendix Seven

Powerpoint Slideshow: Minimizing the Impact of Development on Water Resources

Slide 1



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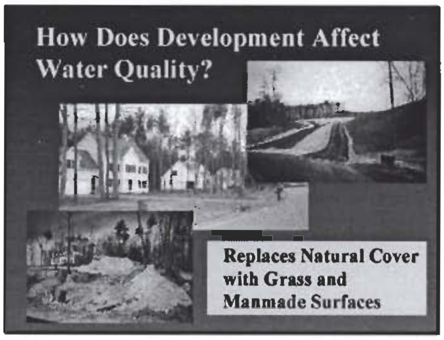

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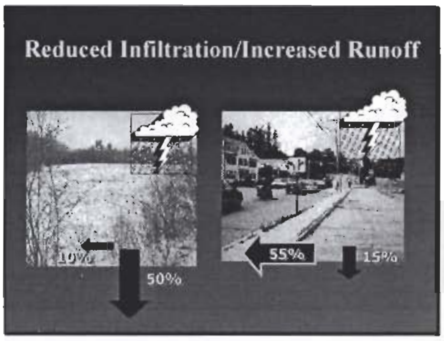

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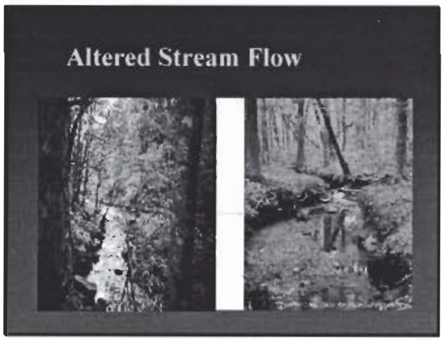

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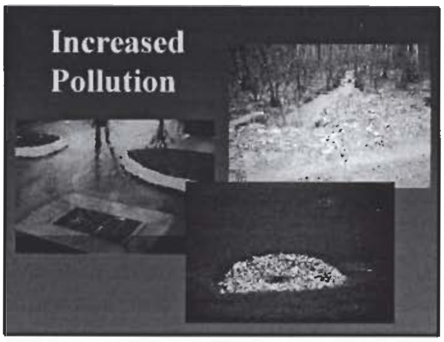

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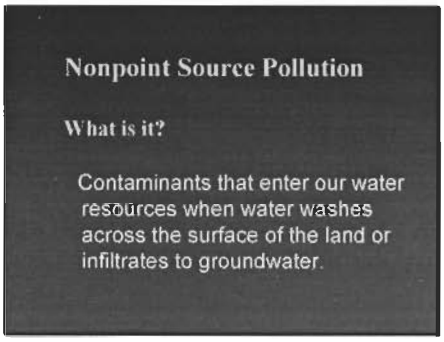

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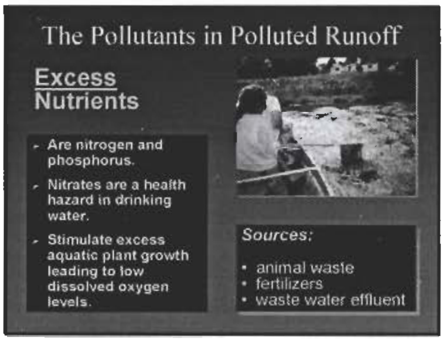

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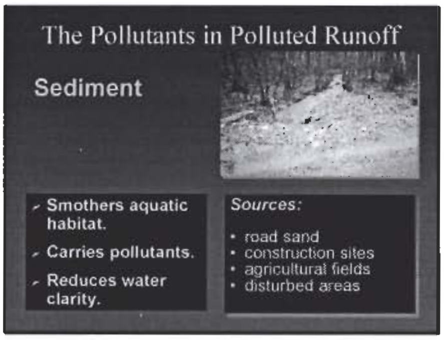

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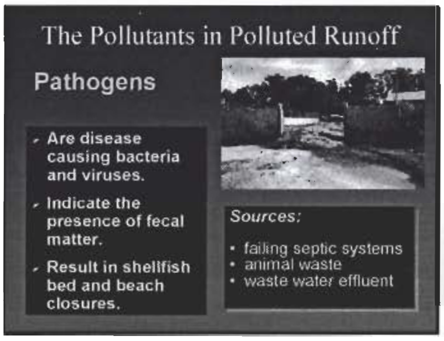

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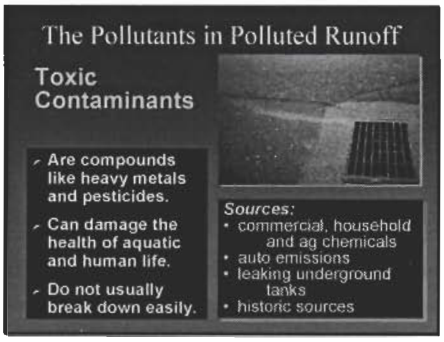

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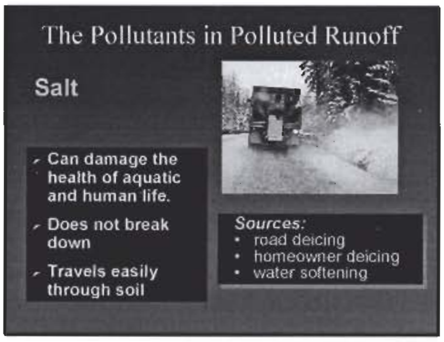

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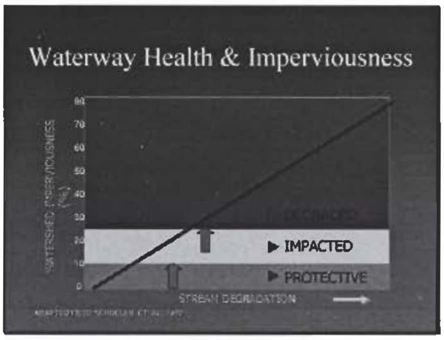


Slide 13

How to Protect Water Resources

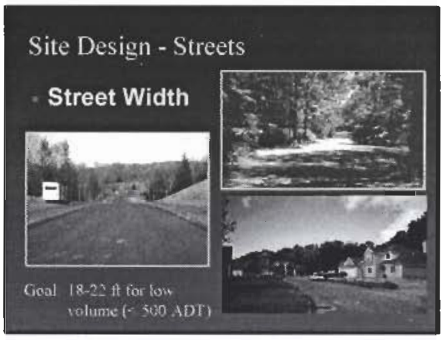
- Reduce Impervious Cover
- Maintain Water Cycle
- Limit Disturbance/Maintain Natural Areas
- Protect Critical Areas

Slide 14

How to Protect Water Resources

- Site Design
- Conservation Subdivision
- LID Stormwater Management
- Location of Development in the Watershed

Slide 15



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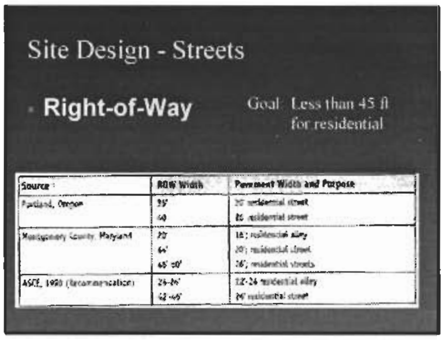
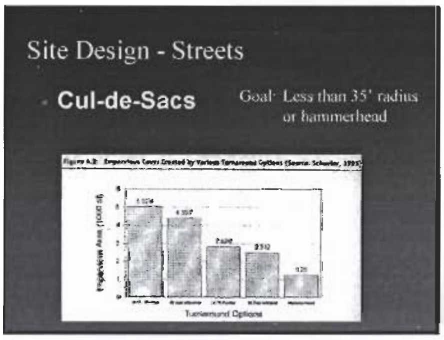


Source	ROW Width	Pavement Width and Purpose
Portland, Oregon	35' 40'	20' residential street 26' residential street
Montgomery County, Maryland	20' 64' 65'-80'	18'; residential alley 20'; residential street 26'; residential streets
ASCE, 1990 (Recommendation)	24-26' 42-46'	12-24 residential alley 24' residential street

Slide 18



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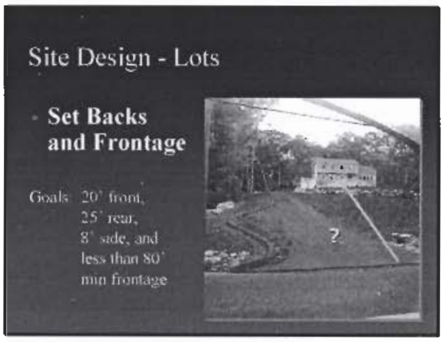

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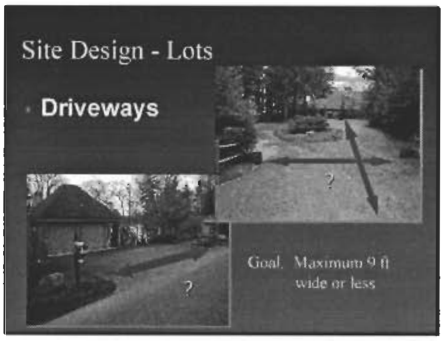

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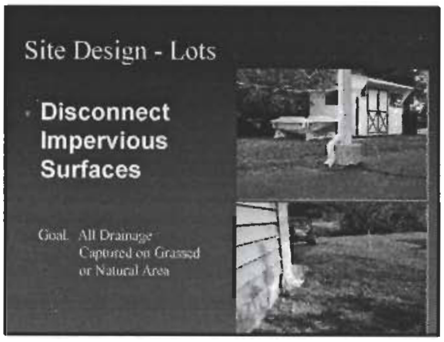

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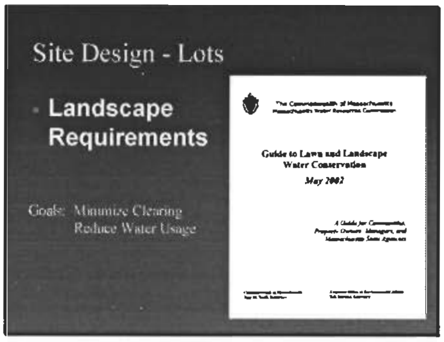

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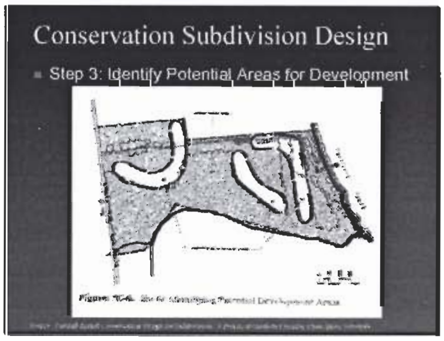

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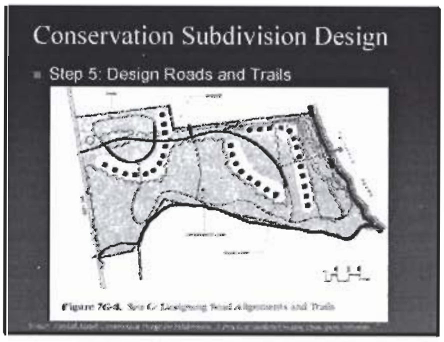

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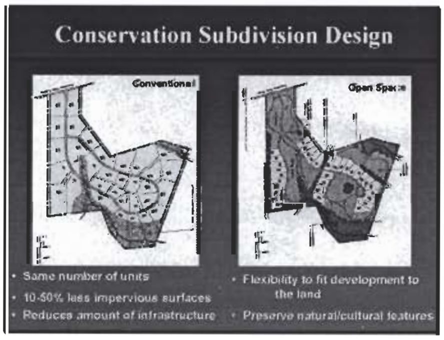

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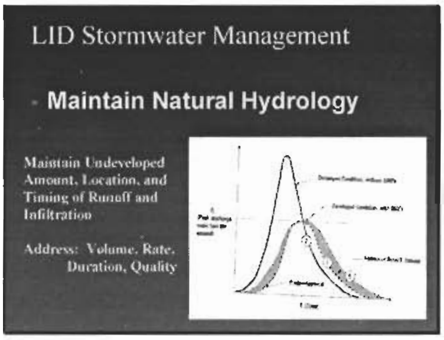

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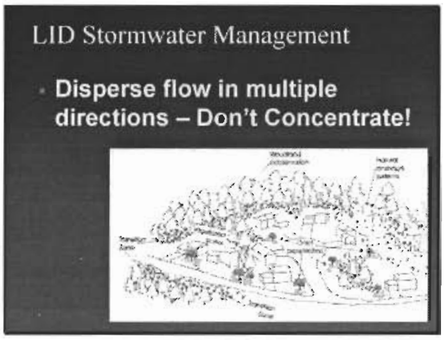

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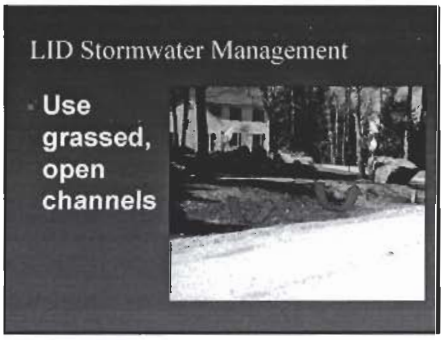

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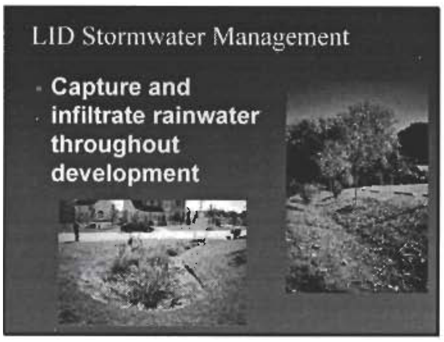

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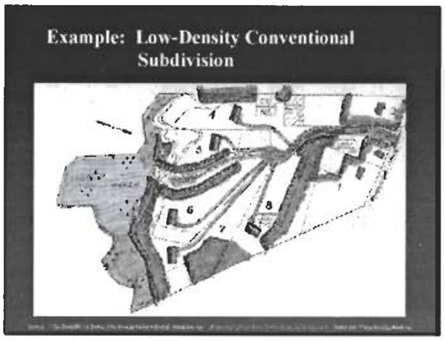

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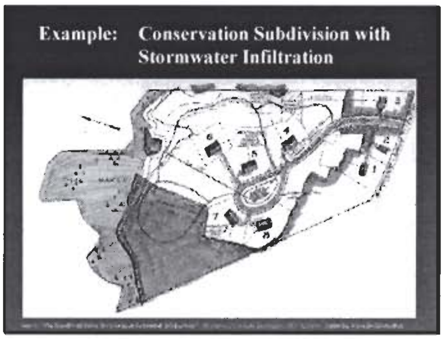

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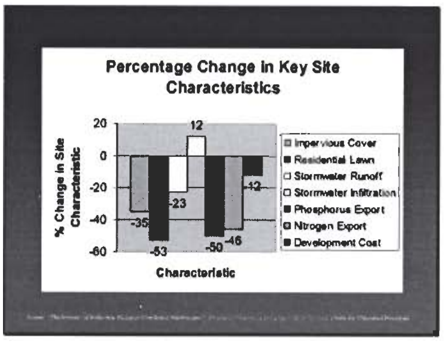

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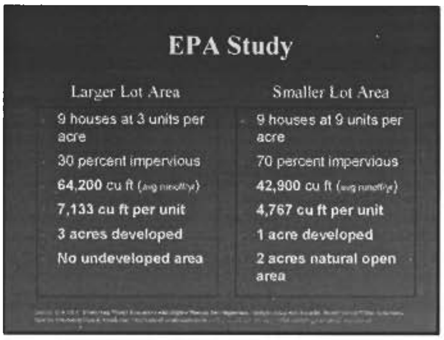

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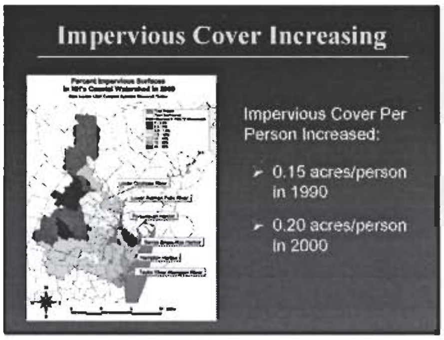

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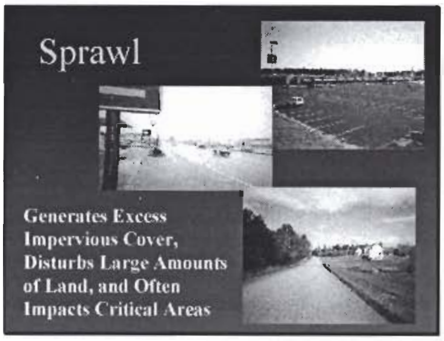

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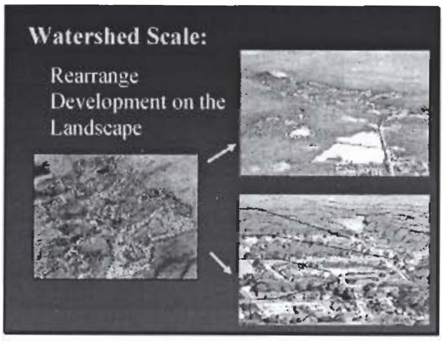

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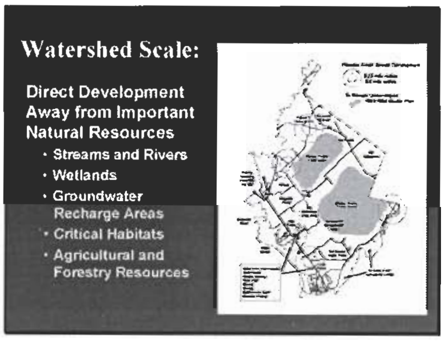

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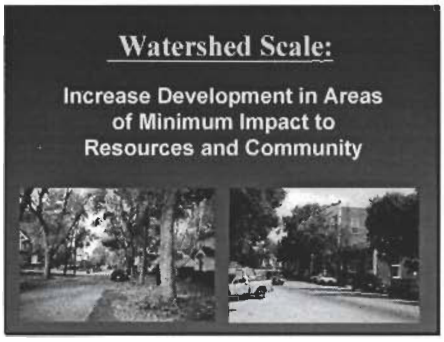

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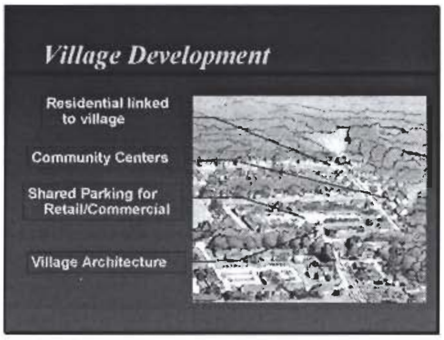

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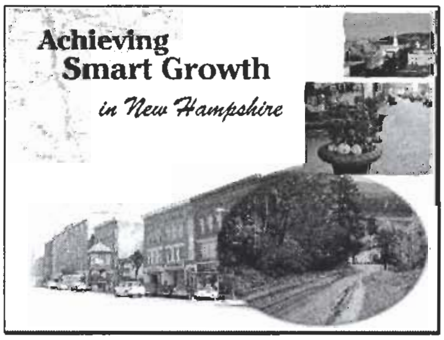


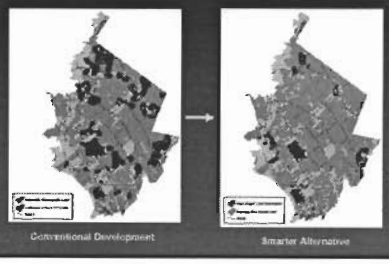
Slide 46

Smart Growth Principles

-Maintain traditional compact settlement patterns...
-Foster the traditional character of New Hampshire downtowns, villages, and neighborhoods...
-Incorporate a mix of uses...
-Preserve New Hampshire's working landscape...
-Provide choices and safety in transportation...
-Protect environmental quality...
-Involve the community...
-Manage growth locally in the New Hampshire tradition, but work with neighboring towns...

Slide 47

Community Scale

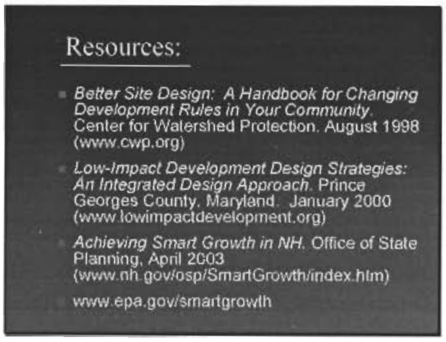


Slide 48

Next Steps:

- Adopt 8 Principles of Smart Growth
- Recognize and Encourage Use of Practices to Protect Water Resources in Regional Plan
- Encourage Local Communities to Pursue these Practices

Slide 49


Resources:
Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection. August 1998 (www.cwp.org)
Low-Impact Development Design Strategies: An Integrated Design Approach. Prince Georges County, Maryland. January 2000 (www.lowimpactdevelopment.org)
Achieving Smart Growth in NH. Office of State Planning, April 2003 (www.nh.gov/osp/SmartGrowth/index.htm)
www.epa.gov/smartgrowth

Appendix Eight

Low Impact Development

Low-Impact Development: Taking Steps to Protect New Hampshire's Surface Waters

What is Low-Impact Development?
Low-impact development (LID) is an approach to site development and design that provides increased opportunities for stormwater infiltration and increased hydrologic function within a watershed. This means that runoff is infiltrated into the ground instead of flowing to the nearest waterbody and, as a result, the natural hydrology of the area can function closer to the way it would have before development.

The benefits of infiltrating runoff include reduction of the frequency and magnitude of flooding, and increased groundwater recharge rates, potentially making more groundwater available for municipal and domestic use and breaking down pollutants in the runoff as it travels through the soil. LID also limits the negative impacts development may have on wildlife habitat and other natural features and helps to maintain or improve ecosystem health. LID can be implemented to reduce habitat fragmentation, allowing for more continuous open space and a healthier local environment.

The LID approach to development may be incorporated into a new development and can also be used to update and improve upon existing development. The focus of LID is the use of on-site techniques that reduce, or even eliminate, runoff as well as control the flow and direction of stormwater, while maintaining existing hydrologic features, such as functional wetlands and naturally flowing streams. This development approach can be encouraged through the creation of watershed districts and ordinances and can protect and improve the quality of New Hampshire's lakes and ponds.

LID Planning Fundamentals
When planning to use LID in conjunction with any development project, there are a few basics to keep in mind:

- It is important to have a good understanding of the hydrology of the site, as hydrologic features and function should be the foundation for new development. This would include considering where streams, rivers, lakes, ponds and wetlands are located, and reducing or eliminating disturbances to these waterbodies.
- When working with existing development, hydrology is important too, as it is possible to use the natural hydrology of the site to dictate which runoff and stormwater control methods are most appropriate and where they should be placed.
- Any new, retrofit or improvement project should be approached with a "micromanagement" approach to stormwater control, as a few small measures can combine to have a large impact.
- Stormwater should also be controlled from the source, when possible, and efforts should be made to prevent runoff and stormwater from reaching any surface waters, including lakes and ponds.
- Finally, using simple, non-structural methods of stormwater control are desirable, while maintaining a multi-functional landscape that is aesthetically pleasing and beneficial to the watershed.

LID Techniques
There are many methods of runoff diversion and retention that fall under the umbrella of LID. They are:

- Efforts should be made to locate any new development close to existing development and roadways and away from surface waters. This allows for easy hook-up to existing utilities, such as sewer pipes, less impervious surface and increased opportunities to collect or treat runoff before it reaches a lake, pond or stream.
- Cluster developments are encouraged, as they increase the amount of common open space and help maintain wildlife corridors.

- To improve upon existing development and to improve surface water quality: vegetation should be used as a filter; runoff should be diverted around sites where pollutants may be picked up, such as gas stations; impervious surfaces should be kept clean to prevent sedimentation; and catch basins and other flow control devices should be kept clear of excess debris so they may function properly when needed.
- General conservation design principles also apply, such as using narrower and shorter streets and driveways, reducing lawn size, limiting impervious surface area, and maintaining significant vegetated buffers.
- Additional control methods include: bioretention areas, rain gardens, grassy swales, infiltration trenches, infiltration basins or ponds, native plantings, green roofs, permeable pavement and dry wells.

LID Protects Lake and Pond Quality
There are many benefits to lakes and ponds when LID measures are implemented. Most of the runoff and stormwater control methods prevent many pollutants from ever reaching nearby surface waters. Sedimentation, one of the largest sources of non-point source pollution in the state, may be reduced and even eliminated within a watershed. Chemical pollutants, such as phosphorus and chlorides, are also collected before reaching the waters of local lakes and ponds.

Reduction in phosphorus loading is highly beneficial to New Hampshire lakes and ponds, as phosphorus is a limiting nutrient and the key element linked to lake aging and decline. Phosphorus also binds readily to soil particles and can be prevented from entering surface waters if runoff infiltrates into the ground, and phosphorus-laden sediment is prevented from traveling through the watershed. Additionally, reducing the amount of phosphorus entering a lake or pond will help to prevent algae blooms, and reduce aquatic plant growth, including exotic, aquatic plants. Reducing runoff also reduces the effects of large storms and spring snowmelt on the watershed, as water levels are more consistent and regulated.

For more information concerning LID, please contact the DES Watershed Division's Biology Section at watershed@des.state.nh.us or (603) 271-2963, or refer to "Chapter 2: Best Management Practices for Developing and Developed Land" in the January 2004 edition of *Best Management Practices to Control Nonpoint Source Pollution: A Guide for Citizens and Town Officials*. This publication is available through the DES Public Information Center, at (603) 271-2975, or on-line at www.des.state.nh.us/wmb/was/2004_npsBMP.pdf

Useful Low Impact Development Resources

http://www.lrc.usace.army.mil/co-r/best_management_practices.htm

http://www.ence.umd.edu/~apdavis/Bioinstallations.htm

http://www.ence.umd.edu/~apdavis/Bioret.htm

http://www.greenworks.tv/stormwater/bioretentionislands.htm

http://www.lid-stormwater.net/

http://www.lowimpactdevelopment.org/

http://www.psat.wa.gov/Programs/LID.htm

http://www.vbco.org/planningeduc0058.asp

http://www.epa.gov/owow/nps/lid/

Appendix Nine

Shoreland Protection Act: Fact Sheets and Recommended Native Plantings

Shoreland Protection

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

SP-4 **1997**

Shorelands Under the Jurisdiction of the Comprehensive Shoreland Protection Act

The NH Comprehensive Shoreland Protection Act (CSPA), RSA 483-B, became effective on July 1, 1994 and established the "protected shoreland." The protected shoreland is all the land located within 250 feet of the "reference line" of public waters.

Within the protected shoreland, certain activities are restricted or prohibited, and others require a permit from the New Hampshire Department of Environmental Services (DES). All activities that are regulated by the DES must comply with applicable local, state, and federal regulations. For a summary of the minimum standards of the Shoreland Protection Act listing activities and the distances they must be set back from the reference line, see DES fact sheet WD-SP-5 or **WD-SP-6** for more complete documentation of the minimum standards. For more information on regulated activities in protected shoreland, contact the DES Public Information and Permitting Office (PIP).

The protected shoreland is the area of land that exists between the reference line and 250 feet from the reference line. The reference line is the delineation between the water and the land for purposes of this act. The actual definition of the reference line is different for each type of waterbody. Waterbodies that fall under the jurisdiction of the CSPA are listed below as well as the definition of the reference line for each waterbody type.

Lakes and Ponds

All fresh waterbodies listed in the *Official List of Public Waters* published by DES are under the jurisdiction of the CSPA; this includes great ponds and artificial impoundments.

The **reference line for fresh waterbodies** is determined in one of three ways:

A. For **natural fresh waterbodies without artificial impoundments,** it is the natural mean high water level as determined by the DES.

B. For **artificially impounded fresh waterbodies with established flowage rights,** it is the limit of the flowage rights.

C. For **artificially impounded fresh waterbodies without established flowage rights,** it is the waterline at full pond as deter-mined by the elevation of the spillway crest.

Coastal Waters

All coastal waters subject to the ebb and flow of the tide, including the Great Bay Estuary and the associated tidal rivers, are under the jurisdiction of the CSPA. The reference line for coastal waters is the highest observable tide line, which means a line defining the furthest landward limit of tidal flow. This does **not** include storm events, which can be recognized by indicators such as the presence of a strand line of flotsam and debris, the landward margin of salt tolerant vegetation, or a physical barrier that blocks further flow of the tide.

Rivers

The jurisdiction of the CSPA includes most major rivers and river segments, with certain exceptions. All rivers determined to be fourth order or higher using the Strahler method are under the jurisdiction of the CSPA. A listing of these ***Fourth Order Streams and Higher*** was compiled by the **Office of State Planning** (OSP), and can be obtained from OSP at (603) 271-2155 or the DES PIP Office at (603) 271-2975.

The reference line for streams and rivers under the jurisdiction of the CSPA is the ordinary high water mark. The ordinary high water mark is defined as the line on the shore, running parallel to the main stem of the river, established by the fluctuations of water. It is indicated by physical characteristics such as a clear, natural line impressed on the immediate bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas. Where the ordinary high water mark is not easily discernible, the ordinary high water mark may be determined by DES.

Fourth order streams that may be exempt from the Shoreland Protection Act are rivers or river segments designated under the New Hampshire Rivers Management and Protection Program prior to January 1, 1993. Shoreland protection for these rivers, or river segments, designated into the NH Rivers Management and Protection Program is the responsibility of the local river management advisory committee and local municipalities. Among other responsibilities, the local river management advisory committee is responsible for developing a river corridor management plan. For a list of designated rivers and more information on the **New Hampshire Rivers Management and Protection Program** see DES fact sheet R&L-2.

Shoreland Protection

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

SP-6 **1997**

Minimum Shoreland Protection Standards, RSA 483-B

LIMITS WITHIN THE PROTECTED SHORELAND
Prohibited Uses (*RSA 483-B:9, II*) **250 ft**

· Establishment/expansion of salt storage yards, auto junk yards, solid waste & hazardous waste facilities.
· Use low phosphate, slow release nitrogen fertilizer from 250 feet to 25 feet.

Uses Requiring State Permits

· Public water supply facilities (*RSA 483-B:9, III*)
· Public water & sewage treatment facilities (*RSA 483-B:9, IV*)
· Public utility lines (*RSA 483-B:9, IV-b*)
· Existing solid waste facilities (*RSA 483-B:9, IV-c*)
· All activities regulated by the DES Wetlands Bureau per RSA 482-A (*RSA 483-B:9, II(c)*)

Other Restricted Uses

· All new lots, including those in excess of 5 acres, are subject to subdivision approval by DES. (*RSA 483-B:9, V(b)(1)*)
· Setback requirements for all new septic systems are determined by soil characteristics. (*RSA 483-B:9, V(b)(2)*)
· Minimum lot size in areas dependent on septic systems determined by soil type. (*RSA 483-B:9, V(e)(1)*)
· Alteration of Terrain Permit standards reduced from 100,000 square feet to 50,000 square feet. (*RSA 483-B:6, I(d)*)
· Total number of residential units in areas dependent on on-site sewage & septic systems, not to exceed 1 unit per 150 feet of shoreland frontage. (*RSA 483-B:9, V(e)(2)*)

NATURAL WOODLAND BUFFER RESTRICTIONS (*RSA 483-B:9, V(a)*) **150 ft**

· Where existing, a natural woodland buffer must be maintained.
· Tree cutting limited to 50% of the basal area of trees, and 50% of the total number of saplings in a 20 year period. A healthy, **well-distributed stand** of trees, saplings, shrubs, and ground covers must be maintained.
· Stumps and their root systems must remain intact in the ground within 50 feet of the reference line.
· The opening for building construction is limited to 25 feet outward from the building, septic system, and driveway.
· The opening for accessory structures is limited to 10 feet outward from the footprint.

NEW SEPTIC SYSTEM LEACHFIELD SETBACKS (*RSA 483-B:9, V(b)(2)*)

· 125 feet where soil down gradient of leachfield is porous sand & gravel. **125 ft**
· 100 feet where soil maps indicate presence of soils with restrictive layers within 18 inches of natural soil surface. **100 ft**
· 75 feet where soil map indicates presence of all other soil types. **75 ft**
· 75 feet minimum setback from rivers.

PRIMARY BUILDING LINE*

· Primary structure setback 50 feet from the reference line. (*RSA 483-B:9, II(B)*)	**50 ft**
· Fertilizer use is prohibited within 25 feet of reference line. (*RSA 483-B:9, II(d)*)	**25 ft**
· Accessory structure setback 20 feet from the reference line. (*EnvWs 1405.04*)	**20 ft**

REFERENCE LINE (*RSA 483-B:4, XVII*)

· For coastal waters = highest observable tide line
· For rivers = ordinary high water mark
· For natural fresh waterbodies = natural mean high water level
· For artificially impounded fresh waterbodies = water line at full pond

* If a municipality establishes a shoreland setback for primary buildings, whether greater or lesser than 50 feet, that defines the Primary Building Line for that municipality.

Thursday, Jul. 14, 2005

Home

About DES
DES Programs
Public Information
Rules/Regulatory
Business Center
OneStop Data

What's New?

A-Z Topics List

Contact DES
Site Search

Shoreland Protection

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

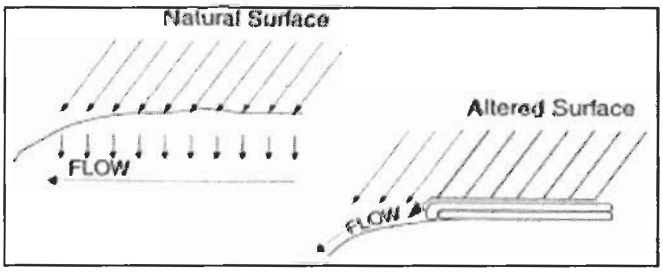
SP-7 **2000**

Accessory Structures in Protected Shoreland

Any time the natural soil surface is disrupted the ability of the ground to absorb storm water is altered. Even a seemingly mild change from forest mat to lawn can drastically increase the likelihood of water flowing across the surface.

Structures typically have a more drastic effect by producing some combination of the following circumstances.

1. Decreasing the ability of the ground to absorb storm water and promoting surface runoff.
2. Increasing the potential for erosion if the structure itself is water permeable.



The surface flow of water in any place but an established streambed has the potential to cause significant erosion which can result in major damage to an aquatic ecosystem. The most visible and costly result can be a loss of water clarity due to increased algae growth. The Comprehensive Shoreland Protection Act was developed to address these concerns.

The New Hampshire Comprehensive Shoreland Protection Act sets minimum standards for the use and development of property within 250 feet of public waters, including the installation of structures.

For more information on the protected shoreland and public waters see NH DES Fact Sheet WD-BB-34, **RSA 483-B** and **Env-Ws 1400**, or visit our web site at **www.des.state.nh.us/cspa**.

Structures

The Comprehensive Shoreland Protection Act divides structures into two categories, primary and accessory.

Primary structure "means a structure other than one which is used for purposes wholly incidental or accessory to the use of another structure on the same premises." (**RSA 483-13:4XIV**.)

Accessory structure "means a structure detached from the primary building on the same lot and customarily incidental and subordinate to the primary building or use, such as a pump house, gazebo or woodshed." (**RSA 483-B:4 II**.)

For more information on primary structures refer to **RSA 483-B:9II(b)**.

Structure? What Structure?

It is important to note not all accessory structures are specifically identified in the statute or the rules. What is or is not considered a structure is explained in the definition of structure.

Structure "means anything built for the support, shelter or enclosure of persons, animals, goods, or property of any kind, as well as anything constructed or erected with a fixed location on or in the ground, exclusive of fences." (RSA 483-B:4 XXII.)

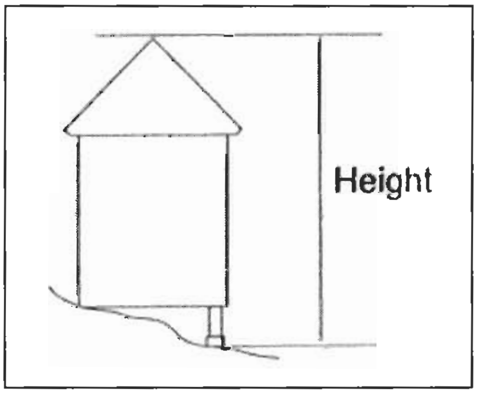
Some examples of structures:

- Patios, walkways, and parking areas
- Underground storage tanks (USTs)
- Camping trailers and RVs
- Stone walls
- The fill extension of a Septic system or a roadway is considered part of the structure.
- Grading and contour changes are not considered structures, however, they are subject tb the restrictions of the Natural Woodland Buffer (RSA 483-B:9 (a). This means if trees must be cleared within the woodland buffer or stumps must be removed within 50 feet of public water, the grade must remain unchanged.

  NOTE: IT IS NOT POSSIBLE TO IDENTIFY EVERY CONCEIVABLE STRUCTURE THAT CAN BE CONSTRUCTED IN PROTECTED SHORELAND. IF THERE IS ANY QUESTION ABOUT WHAT IT IS YOU ARE BUILDING, PLEASE CALL US AT (603)271-7109.

Minimum Standards for Small Accessory Structures

- Accessory structures must be set back 20 feet from public waters.
- Accessory structures can have a maximum coverage area (footprint) no larger than 150 square feet.
- Accessory structures can be no higher than 20 feet from lowest contour to peak.
- Accessory structures can not be constructed on a slope greater than 25%.
- Accessory structures cannot be constructed unless they are allowed under local regulations.



Accessory structures may be closer than 20 feet in the following circumstances.

- The structure is a water dependent structure such as a dock, and will not work unless it is either over or in the water, and a permit from the wetlands bureau has been obtained.
- A walkway no greater than 4 feet wide and provides access to the water or a

water dependent structure.
- A water drainage structure, such as a swale, the purpose of which is to provide a stable conveyance of water to the public water.

What if the proposed structure meets the setback but not the size requirements?

Accessory structures larger than the size requirements of small accessory structures must be set back 50 feet from the reference line.

Other Minimum Standards

Like all structures, accessory structures are required to have temporary and permanent erosion control in accordance with **RSA 483-B:9(c)**. For more information on erosion control see the *Best Management Practices for Stormwater Management and Erosion and Sediment Control*.

The construction of any building that is serviced with running water must have a state approved septic system design. This includes the replacement of buildings that have been demolished or burned, reconstruction of a building in a new location, or expansion of the existing structure. These projects are considered new construction and construction approval in accordance with the Subdivision and Individual Sewage Disposal System Design Rules (**Env-Ws 1000**) is required prior to beginning the project.

Native and Naturalized Shoreland Plantings For New Hampshire

Common Name	Scientific Name	Height	Habitat/Soil Preference
American Beech	Fagus grandfolia	70-80'	Bottomlands, gentle slopes
American Linden	Tilia americana	60-100'	Moist soils of valleys and uplands
Balsam Fir	Abies balsamea	40-60'	Swamps to well-drained soils
Black Tupelo	Nyssa sylvatica	60-80'	Bottomlands, gentle slopes
Common Sassafras	Sassafras albidum	30-40'	Well drained fields & woods
Eastern Hemlock	Tsuga canadensis	60-70'	Moist cool valleys, acidic soils
Eastern White Pine	Pinus strobus	80-100'	Rock ridges, bogs, sandy loam
Green Ash	Fraxinus pennsylvanica	50-60'	Streams, floodplains, moist alluvial soils,
Northern Red Oak	Quercus rubra	60-80'	Bottomlands,slopes,moist soils
Paper Birch	Betula papyrifera	50-70'	Streambanks, lakeshores, moist sandy
Red Maple	Acer rubrum	50-70'	Swamps, bottomlands, moist soils
Red Pine	Pinus resinosa	50-80'	Sandy soils, rocky slopes
Scarlet Oak	Quercus coccinea	70-80'	Dry sandy to gravelly soils
Shadbush	Amelanchier sp.	30-40'	Edges of streams,moist woods,ravine
Smooth-Leaved Shadbush	Amelanchier laevis	Up to 30'	Damp wooded banks, swamps, thickets
Sugar Maple	A. saccharum	60-80'	Uplands, valleys moist rich soils
Swamp White Oak	Quercus bicolor	60-70'	Wet sites, areas of flooding
White Ash	Fraxinus americana	70-80'	Valleys, slopes, moist soil, well-drained loam
White Oak	Quercus alba	80-100'	Uplands, sandy plains, rich soils
Whire Spruce	Picea glauca	60-70'	Streambanks, lakeshores, flats, slopes
Yellow Birch		Up to 100'	Hilly terrain, high elevation

Common Name	Scientific Name	Height	Habitat/Soil Preference
American Cranberry	Viburnum opulus		
American Elder	Sambucus canadenis	3-10'	Swamp edges, along fences and roads
American Hazelnut	Corylus americana	3-8'	Borders of woods, hillsides, thickets
Arrowwood	Viburnum dentatum	3-15'	Wet/dry thickets,borders of woods
Bayberry	Myrica pensylvanica	Up to 6'	Sandy, sterile areas
Beech Plum	Pinus maritima	Up to 8'	Near coast, sandy soil
Black Chokeberry	Aronia meloncarpa	2-4'	Rocky uplands, thickets, clearings
Blackhaw	Viburnum prunifolium	Up to 20'	Valleys, slopes, boders of forests, moist soils
Bog Rosemary	Andromeda glaucophylla	.5-1.5"	Bogs, peaty to sandy soils
Buttonbush	Cephalanthus occidentalis	5-15"	Swamps, borders of ponds, streams
Common Witchazel	Hamamelis virginiana	10-15"	Dry or moist woods
Eastern Red Cedar	Juniperus virginiana	40-50'	Fields, poor dry soils
Gray Dogwood	Cornus racemosa	Up to 9'	Roadsides,thickets,swamps dry or moist.
Highbush Blueberry	Vaccinium corymbosum	5-15"	Swamps or dry upland woods
Hobblebush	Viburnum alnifolium	3-10"	Shrub layer of cooler NE forests
Ironwood	Ostrya virginiana	3-9'	Cool moist forests
Juniper	Juniperus communis	1-3'	Fields, sandy to rocky flats, slopes
Labrador Tea	Ledum groeniacdicum	1-3'	Bogs, High Mountains
Lowbush Blueberry	Vaccinium angustifolium	3-15"	Bogs, dry sandy flats, rocky slopes
Mapleleaved Viburnum	Viburnum acerifolium	3-6"	Shrub layer of moist upland forest
Meadowsweet	Spiraea latifolia	1-5'	Low moist ground, meadows,fields

Common Name	Scientific Name	Height	Habitat/Soil Preference
Mountain Holly	Ilex montana	Up to 30'	Mixed hardwood forest, moist soils
Mountain	LaurelKalmia latifolia	3-15'	Open hardwood forests
Mugo Pine	Pinus mugo	12-15'	Fields, roadsides, wet places
Nannyberry	Viburnum lentago	10-30'	Swamp and forest edges
Pagoda Dogwood	Cornus alternifolia	Up to 25'	Hardwood & coniferous forests,Moist soils
Red Chokeberry	Pyrus arbutifolia	3-12'	Thickets, clearings, swamps
Red Osier Dogwood	Cornus sericea	3-10'	Short thickets
Rhodora	Rhododendron canadense	1-3'	Bogs, wet slopes, rocky summits
St. Johnswart	Hpericum perforatum	1-3"	Fields, roadsides, wet places
Sheep Laurel	Kalmia angustifolia	1-3"	Fields, bogs, dry/wet, sandy/sterile soils
Shinning Sumac	Rhus copallina	Up to 25'	Uplands, valleys, grasslands, clearings
Shrubby Cinquefoil	Potentilla fruticosa	1-3"	Wet or dry open ground, meadows
Silky Dogwood	Cornus amomum	Up to 10'	Wooded swamps, low wet woods, shrub swamps
Snowberry	Symphoricarpos albus	1-4'	Rocky banks and roadsides
Staghorn Sumac	Rhus typhina	3-30'	Fields, clearings, dry soils
Steeplebush	Spiraea tomentosa	2-4'	Old fields, meadows, low grounds
Sweet Pepperbush	Clethra alnifolia	3-10'	Wetlands, swamps, sandy woods
Sweetgale	Myrica gale	Up to 6'	Streams, low wet woods, borders of swamps
Winterberry	Ilex verticillata	3-10'	Swamps, thickets, pond margains
Witherod Viburnum	Viburnum cassinoides	3-12'	Wet thickets, swamps, clearings

Common Name	Scientific Name	Height	Habitat/Soil Preference
Bloodroot	Sanguinaria candensis	Up to 10"	Rich woodlands, streambeds
Bunchberry	Cornus canadensis	3-8"	Cool woods, damp openings
Climbing Bittersweet C	elastrus scandens	Vine	Thickets, woods, riverbanks
Concord Grape	Vistis sp.		
Cowberry	Vaccinium vitus-ideamajus		
Cranberry	Vaccinium macrocarpon	Up to 8"	Open bogs, swamps,lakeshores
Foamflower	Tiarella cordifolia		
Ginger	Asarum sp.		
Hay-Scented Fern	Dennstaedtia punctiloula	Up to 7"	Woodlands, hillside pastures
Interrupted Fern	Osmunda claytoniana		Roadsides, woodland edges, stony dry soil
Lowbush Blueberry	Vaccinium angustifolium	3-15"	Bogs, dry sandy flats, slopes
Marsh Marigold	Caltha palustris	1-2'	Swamps, marshes,streams,brooks
Partridgeberry	Mitchella repens	4-12"	Dry or moist woods
Royal Fern	Osmunda regalis	3-6'	Streams, lakes, bogs, marshes
Sweet Fern	Comptonia peregrina		
Virginia Creeper	Parthenocissus quinquefolia		Woods, rockybanks
Wineleaf Cinquefoil	Potentilla tridentata		
Wintergreen	Gaultheria procumbens	2-6"	Oak woods, sandy soils

Appendix Ten

Towns of Franklin and Deering Zoning Regulations and Overlay Examples

Watershed Districts and Ordinances

What are Watershed Districts and Ordinances?

Watershed district and ordinances are methods of zoning that recognize watershed boundaries instead of political boundaries, as a means of regulating land uses that may affect surface water quality. A watershed district or ordinance may set rules or regulations that restrict certain activities within the watershed in order to protect surface water resources, such as lakes, ponds and rivers. Regulations could include setback requirements, buffer requirements, land use restrictions, implementation of best management practices (BMP) and implementation of low impact development (LID) techniques. Typically, a watershed district or ordinance is proposed by a town or city planning board and must be approved by the voters. Often, the ordinance or district modifies or amends zoning regulations already in place in the towns or cities involved. Watershed districts and ordinances may vary by town and can be tailored to suit the needs of the particular watershed.

How Can Watershed Districts and Ordinances Protect New Hampshire Lakes and Ponds?

This approach to watershed management is beneficial to New Hampshire's surface waters, especially those with expansive watersheds. Within a watershed district or ordinance, towns work together to protect a common resource, such as a lake or pond. A watershed district or ordinance may decrease sedimentation, and nutrient loading to surface waters by taking measures to reduce or eliminate stormwater runoff. In addition, reduction or elimination of the use of hazardous materials within the watershed may prevent dangerous substances from reaching lakes and ponds. In densely developed watersheds, this approach may help to improve water quality. In relatively undeveloped watersheds, this approach may help to protect water quality in the face of future development.

How To Form a Watershed District or Ordinance in Your Community

Forming a watershed district or ordinance involves bringing a lot of different groups together under a shared goal. Often, DES will work with the interested communities and provide as much assistance as possible throughout the process. The first step is to determine which towns are included in the lake or pond's watershed. Town planning boards and conservation commissions should be included in the planning process. Watershed districts and ordinances formed to protect lakes and ponds often involve local lake associations as well. These groups, as well as any other interested groups or individuals, determine what activities will be regulated. Regulated activities may include agriculture, forestry and construction, as well as standards for septic systems. Standards for wetlands and surface water protection may be included as well. Regulations or standards are set for the watershed district or ordinance, and put to a vote within each town. Once the voters of each town in the watershed accept the regulations and standards, the ordinance or district may go into effect.

For more information, or examples of watershed districts or ordinances that have been implemented in New Hampshire, contact Jody Connor, DES Limnology Center Director, at (603) 271-3414 or jconnor@des.state.nh.us.

Watershed Protection Ordinance-preamble
Deering Lake, Deering, New Hampshire

Are you in favor of amending the Zoning Ordinance to add Section 12 Watershed Protection Ordinance as proposed by the Planning Board, to help protect Deering Lake from the effects of pollution and runoff caused by new development within its watershed?

<u>Explanation:</u>

- This Section will create an overlay to the Zoning Ordinance that applies minimal but essential requirements primarily to new development within the Deering Lake watershed that will protect the lake and its water quality from the increased sediment and nutrient run-off that enters the watershed when reasonable practices are not followed.

- Although there have been increases in sediment and nutrient loading caused by new development involving Lake properties, Deering Lake has been able to withstand these increases with little diminishment in water quality. Our lake has water quality that is among the best in NH.

- This will not remain the case as the rapid pace of development continues. A newly-commissioned study calculated the likely damage caused by new development scenarios. This ordinance reflects the findings of that study.

- Deteriorated water quality diminishes wildlife, scenic beauty, and recreational uses and destroys the values of Lake properties.

- Diminished property values affect the tax base of the town.

- This Overlay Ordinance would apply primarily to new development within the defined watershed of Deering lake and would require new subdivisions to demonstrate that they would "do no harm" to the lake and new home construction to include a soil erosion plan. Other development would be required to put in place "best practices" to protect the lake.

WEBSTER LAKE OVERLAY DISTRICT (8/25/04)

Add new Section 309.29.2 to the Franklin Zoning Ordinance

A. Purpose:

a. Webster Lake is a public water body. In as much, the City of Franklin shares with the State of New Hampshire, jurisdiction and responsibility to protect and maintain the quality of this valuable resource for the greatest public benefit.

b. The Webster Lake watershed, which falls within the municipalities of Andover, Hill and Franklin, is a valuable and fragile natural resource and has direct influence on the integrity of the water quality of Webster Lake.

c. Under current local and state laws the potential exists for random, piecemeal or uncoordinated uses of the land within the watershed, which could have significant negative impact on the water quality of Webster Lake, and it's tributaries. The environmental quality of the watershed has been degraded due to agricultural run-off, the destabilization soils from development activities, and the failure of septic systems.

d. The creation of performance standards for certain land use activities within the watershed will provide for increased long-term protection of Webster Lake and its watershed.

e. Where the Webster Lake watershed transcends municipal boundaries, the City of Franklin will seek opportunities to work cooperatively with neighboring towns toward the common objective of improved water quality within the subject watershed. In the spirit of a regional approach to resource management, the City will foster cooperation among regional and state officials to further enhance the quality of water found in this overlay district.

B. Authority:

a. Under RSA 674:16 the Planning Board has the authority to promulgate recommendations to modify or create zoning changes and for the City Council to adopt such recommended changes.

b. RSA 674:21 Innovative Land Use Controls sections (h) and (j) allow municipalities to adopt ordinances which contain performance standards and environmental characteristics zoning that allow the City to promulgate standards to ensure the continued integrity of these natural resources.

c. In any case where a provision of these regulations is found to be in conflict with provisions of other regulations, ordinances or codes of either the State or the City, the provisions, which are more restrictive, shall prevail.

C. DEFINITIONS:

1. Bank: the transitional slope adjacent to the edge of a surface water, the upper limits of which is usually defined by a break in slope or, for a wetland, where a line delineated in accordance with DES Administrative Rules Wt. 301.01 indicates a change from wetland to upland area.
2. Individual Sewage Disposal System: as defined by the NH Department of Environmental Services [NH DES] and associated Code of Administrative Rules, as amended.
3. Surface Water or Surface Water Body: any portion of the waters of the state, which have standing or flowing water at or on the ground. This includes, but is not limited to, rivers, streams (perennial or intermittent), lakes, or ponds.
4. Watershed: a geographic area in which all water drains to a given stream, lake, estuary, or ocean.
5. Webster Lake Watershed: The Webster Lake Watershed consists of the area shown on the map titled Webster Lake Watershed Land Use, prepared by NH DES, October 2003.
6. Webster Lake Watershed Overlay District: The area shown as the Overlay District on the map attached to the Franklin Zoning Ordinance and which is subject to the provisions contained herein.
7. Wetland: an area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions does support, a prevalence or vegetation typically adapted for life in saturated soil conditions. Wetlands include, but are not limited to, swamps, marshes, bogs, wet meadows, and other similar areas

<u>PERFORMANCE STANDARDS</u>

D. AGRICULTURE (Includes any agricultural activities)

1. Livestock are not allowed direct access to surface waters. Drinking water for livestock shall be provided by the use of a tub or other container located a minimum of 150 feet away from any surface water or wetland.
2. Application of fertilizers or pesticides is not allowed within 200 feet from any surface water or wetland.
3. All livestock grazing and feeding areas shall be a minimum of 200 feet away from surface waters.
4. All runoff from livestock feeding areas shall be directed away from surface water or wetland area.
5. No spreading of animal manure on fields or pastures is allowed any closer than 200 feet away from any surface water or wetland. No stockpiling of manure is allowed any closer than 200 feet from any surface water or wetland area and the stockpiling must be placed on an impervious surface and contained to prevent the release of leachate.
6. Unless stricter setbacks or operational requirements are outlined above, all agricultural operations shall be conducted in accordance with the <u>Manual of Best Management Practices for Agriculture in New Hampshire</u>, NH Dept. of Agriculture, June 1993, as amended, and in accordance with all appropriate sections of the Comprehensive Shoreland Protection Act, as amended.

E. WETLANDS and SURFACE WATERS

1. No filling, alteration, or any other work is allowed within any wetland area without the required permits from the NH DES.
2. The property owner or his/her designee is responsible for obtaining all necessary state or federal permits pertaining to, but not necessarily limited to, the construction and/or installation of any docks, boathouses, footpaths or steps to the water. Copies of all permits shall be submitted to the Franklin Conservation Commission.
3. For any plans or designs required as part of this Overlay District which involves analysis and determination of wetland boundaries, the work to determine said boundaries whall be done by a Certified Wetland Scientist and/or a Certified Soil Scientist as defined by RSA 310-A:76 II. and III, as amended.

F. FORESTRY (Includes all commercial forestry activities)

1. A minimum 75-foot undisturbed natural vegetated buffer shall be maintained adjacent all surface waters or wetland areas.
2. Unless stricter setbacks or operational requirements are outlined above, all forestry operations shall be conducted in accordance with the Best Management Practices for Erosion Controls on Timber Harvesting Operations in New Hampshire, NH Division of Forests and Lands, February 2000, as amended, and in accordance with all appropriate sections of the Comprehensive Shoreland Protection Act, as amended

G. SITE CONSTRUCTION (Commercial / Industrial or Residential)

1. No new structures or driveways are allowed within 50 feet of any surface water or wetland area. Accessory structures are allowed when permitted by the NH DES
2. The impervious area of any building lot is limited to 30%. Impervious area includes building area, gravel or asphalt driveway and parking area.
3. For any use that will render impervious more than 20% or more than 2,500 square feet of any lot, whichever is greater, a storm water management and erosion control plan, consistent with Storm water Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire, Rockingham County Conservation District, August 1992, as amended, shall be prepared and submitted to the Planning and Zoning Office for review. No building Permit shall be issued until such time as the Planning and Zoning Administrator has reviewed and approve said plan.

H. SEPTIC SYSTEMS

1. For any new construction, no Individual Sewage Disposal System [ISDS] shall be installed any closer than 100 feet to any surface water or wetland area.
2. For any expansion of an existing structure, or the seasonal conversion of an existing structure, the owner shall conform to RSA 485-A: 38 and the associated Code of Administrative Rules for Subdivision and ISDS Design Rules, as amended.
3. For a new subdivision development for which ISDS's are proposed, if the lots are under 5 acres, then all plans and permit application shall conform to all relevant NH DES rules and regulations. For lots that are greater than 5 acres, all plans and permit applications shall show an area of 4000 sq. ft., with test pit and percolation test data to verify the site suitability for a septic system.

4. If any septic assessment or an on-site inspection, indicates that the existing system is in failure, a plan for a replacement system shall be submitted to NH DES within the next 30 days.

I. GENERAL PERFORMANCE STANDARDS FOR ALL ACTIVITIES AND LAND USES

1. No new underground storage tanks for flammable or combustible liquid fuels shall be allowed.

J. EXCEPTIONS

1. If the property owner or his/her designee can document that property, or a portion of a property, which is shown to be inside of the Webster Lake Watershed Overlay District is outside of the Webster Lake Watershed, and said documentation is accepted by the Planning and Zoning Administrator, then the provisions of the Webster Lake Watershed Overlay District shall not apply.

K. ENFORCEMENT

1. The Enforcement of these provisions shall adhere to the provisions of Section 305.38 of the Franklin Zoning Ordinance.

Deering Lake Watershed Protection Ordinance

SECTION 12: WATERSHED PROTECTION ORDINANCE
(Adopted March 9, 2005)

12.1 Authority and Statement of Intent

a. Pursuant to RSA 674: 21, the Town of Deering adopts a Watershed Protection Overlay Zone, and accompanying regulations to ensure the protection and preservation of Deering Reservoir, hereafter referred to as Deering Lake, the Deering Lake watershed and the water bodies within the Watershed Protection Overlay Zone from the effects of point and non-point source pollution or sedimentation . The establishment of the Watershed Protection Overlay Zone and the adoption of these regulations are intended:
   (1) to protect public health,
   (2) to protect aquifers, which serve as existing or potential water supplies, and the aquifer recharge system
   (3) to protect surface waters and wetlands contiguous to surface waters,
   (4) to protect the natural areas and wildlife habitats within the Watershed Protection Overlay Zone by maintaining ecological balances, and
   (5) to prevent the degradation of the water quality through the regulation of land uses and development within the Watershed Protection Overlay Zone.

b. Within this district, and in the event of a conflict between the requirements of this section and other provisions of the Deering Zoning Ordinance or state law, the more stringent requirement shall govern.

12.2 Applicability

a. The special provisions established herein shall apply to all development proposals and to potential contaminating activities within the Watershed Protection Overlay Zone, and all such proposals and activities shall be subject to the review requirements set forth in Section 12.6. The boundaries of the Watershed Protection Overlay Zone have been delineated by the Planning Board using current location data. The Watershed Protection Overlay Zone is shown on the master zoning map kept on file in the Town Hall.

b. The boundaries of the Watershed Protection Overlay Zone may be identified through drainage, groundwater and soils analyses and are considered to be essential to the protection of the watershed from the effects of point and non-point source pollution or sedimentation. These boundaries may be modified as necessary by the Planning Board as new data becomes available.

12.3 Administration

a. General: The Deering Planning Board shall have sole and exclusive authority to administer the provisions of the Watershed Protection Ordinance. The Planning Board is further authorized to adopt amendments to the subdivision regulations in order to further administer the requirements of this section. All development proposals and other potential contaminating activity occurring wholly or partly in an area within the Watershed Protection Overlay Zone shall be subject to this Ordinance and to review and approval by the Planning Board as specified herein. Such review and approval shall be in addition to that required by statute, other provisions of the Deering Zoning Ordinance or Planning Board's rules or regulations. Such review, approval, and all conditions attached to the approval shall be properly documented before issuance of any building permit by the Town. Initial reviews and evaluations required by Section 12.6 c. shall be conducted by the Town of Deering Planning and Zoning Administrator on behalf of the Planning Board. If it is desired to have the full Planning Board consider an initial review or evaluation, a request for full Board consideration must be filed with the Planning and Zoning Administrator within 3 weeks of its issuance. If no such request is filed, the initial evaluation will become final.

b. Enforcement: The Board of Selectmen shall be responsible for the enforcement of the provisions and conditions of this Watershed Protection Ordinance, pursuant to the provisions of Section 7.

12.4 Definitions

a. Buffer Zone. The undisturbed natural area sufficient in size to mitigate runoff effects harmful to water quality.

b. Contamination. Sedimentation, point and non-point source pollution, septage, or the discharge of hazardous materials.

c. Development. Any construction, change in use, external repair, land disturbing activity, grading, road building, pipe laying, or other activity resulting in a change in the physical character of any parcel of land.

d. Hazardous Materials. As defined in Superfund Amendment and Reauthorization Act of 1986 and Identification and Listing of Hazardous Wastes, 40 C.F.R. §261 (1987).

e. Hydrology. The study of the earth's waters, their distribution and the cycle involving precipitation, infiltration into the soil and evaporation.

f. Impervious surface. An area whose water absorbing characteristics are greatly reduced as compared to the natural land and therefore less easily penetrated by moisture including, but not limited to, dirt and paved roads, driveways, parking lots, sidewalks, and roofs.

g. Infiltration rate. The amount and measure of time for surface water to filter into the soil.

h. Potential Contaminating Activity. Activities that have the potential to create a new discharge of contaminants or to increase the discharge of contaminants to surface or ground-waters.
i. Runoff Volume. The measure of surface water runoff during a storm event.
j. Sedimentation. The deposition of sand, silt, soil or other matter into a watercourse or wetland, including that resulting from post-development surface runoff.
k. Storm event. A period of sustained rainfall with a minimum total accumulation of 0.25 inches of precipitation over a 24 hour period.
l. Storm water. Surface water runoff from a non point source caused by a storm event.
m. Tributary stream. Any perennial or intermittent stream, flowing either directly or indirectly into Deering Lake.
n. Watershed. The area lying within the drainage basins of Deering Lake.
o. Non-point Source Pollution. Contaminants including, but not limited to; pesticides, fertilizers, animal wastes, sediments, nutrients, and heavy metals that are deposited on the ground surface and that may flow into and pollute nearby surface waters.
p. Best Management Practices. As defined in "Innovative Stormwater Treatment Technologies, Best Management Practices Manual-May 2002" and "Best Management Practices to Control NonPoint Source Pollution, A Guide for Citizens and Town Officials-January 2004" prepared by the New Hampshire Department of Environmental services and "Buffer for Wetlands and Surface Waters, a guidebook for New Hampshire Municipalities" May 1997 or any updated versions thereof.

12.5 Use regulations

a. Permitted uses, special exception uses, accessory uses, dimensional standards and special requirements established by the underlying zoning district shall apply, except as modified below:
b. The following uses shall be specifically prohibited within the Watershed Protection Overlay Zone:
   (1) Storage or production of hazardous materials as defined in either or both of the following:
      (a) Superfund Amendment and Reauthorization Act of 1986.
      (b) Identification and Listing of Hazardous Wastes, 40 C.F.R. §261 (1987)
   (2) Disposal of hazardous materials or solid wastes
   (3) Treatment of hazardous material, except rehabilitation programs authorized by a government agency to treat hazardous material present at a site prior to the adoption of this ordinance.
   (4) Dry-cleaning, dyeing, printing, photo processing and any other business that stores, uses, or disposes of hazardous material, unless all facilities and equipment are designed and operated to prevent the release or discharge of hazardous materials and have undergone an inspection by the Town of Deering Code Enforcement Officer to certify they are in compliance with hazardous material regulations.

(5) Disposal of septage or septic sludge, as defined by New Hampshire Solid Waste Rules Env-Wm101-300 & 2100 - 3700.
(6) Automobile service and repair stations
(7) Junkyards and Salvage Yards

12.6 Review requirements for Development in the Watershed Protection Overlay Zone

a. **General.** Applications for subdivision of land and for site plan review and approval are subject to all review requirements of this Section, including the requirement in 12.6 b. that they shall be accompanied by a hydrologic study. Applications for new home construction, and additions, modifications and repairs of existing homes, need not be accompanied by a hydrologic study, but must meet the other review requirements of this Section. New home construction applications must include a soil erosion plan as set forth in 12.6 c. This Watershed Protection Ordinance does not establish any pre-approval requirements for other land development proposals that do not involve potential contamination.

b. Any application for a land development proposal involving the subdivision of land or site review and approval, occurring wholly or partly in the Watershed Protection Overlay Zone, shall be submitted to the Planning Board for approval and shall be accompanied by a hydrologic study prepared in accordance with the requirements set forth in subsection 12.7 below. Said study must document, in a manner acceptable to the Planning Board, that the land development proposed would provide the same or a greater degree of water quality protection as existed on the site(s) in question at the time the application is made.

c. All development within the Watershed Protection Overlay Zone will be evaluated by the Planning Board to ensure that:

(1) Non-point source pollution is prevented to the maximum extent possible, taking into account site conditions such as slope, soil type and erosivity, and vegetative cover. The amount of lawn is limited to 10% of all dry land.

(2) Best Management Practices (BMPs) are in place sufficient to remove or neutralize those pollutants that present a potential impact to the water body. In the case of proposals for new home construction, the proposal shall include an erosion and sedimentation control plan prepared by a licensed engineer. The use or creation of holding-ponds is not allowed for runoff control.

(3) Grading and removal of vegetation at a development site is minimized and erosion and sedimentation control measures are in place and properly installed.

(4) All septic tanks will be pumped and inspected by a State of New Hampshire licensed septic services provider to ensure proper functioning and a copy of the pumping and inspection report shall be sent to the Town of Deering Planning and Zoning Administrator within 30 days of its occurrence. Such pumping and inspection shall occur at least every three years or at the interval recommended by

the licensed septic service provider in writing at the time of last service. If two or more dwelling units share a common sewage treatment system, a perpetual maintenance agreement binding the dwelling owner is required.

(5) Activities involved in potential contamination within the Watershed Protection Overlay Zone, but which have received a special exception, must submit a spill prevention control and countermeasures plan (SPCC Plan) for approval. This plan shall include the following elements:
   (a) Disclosure statements describing the types, quantities, and storage locations of all contaminants that will be part of the proposed project.
   (b) Contaminant handling and spill prevention techniques
   (c) Spill reporting procedures, including a list of affected agencies to be contacted in the event of a spill
   (d) Spill recovery plans, including a list of available equipment
   (e) Spill clean-up and disposal plans

d. Existing land uses located within the Watershed Protection Overlay Zone and identified as potential contaminating activities by the Planning Board shall comply with the requirements of Section 12.6, Subsection c.(5) listed above.

12.7 Hydrologic Study

a. A hydrologic study shall be performed by a registered professional engineer or hydrologist and it shall include, at a minimum, the following information:
   (1) Description of the proposed project including location and extent of impervious surfaces; on-site processes or storage of materials; the anticipated use of the land and buildings; description of the site including topographic, hydrologic, and vegetative features.
   (2) Characteristics of natural runoff on the site and projected runoff with the proposed project, including its rate and chemical characteristics deemed necessary to make an adequate assessment of water quality.
   (3) Measures proposed to be employed to reduce the rate of runoff and pollutant loading of runoff from the project area, both during construction and after.
   (4) Proposed runoff control and watershed protection measures for the site. These measures shall be designed with the goal of ensuring that the rate of surface water runoff from the site does not exceed pre-development conditions and that the quality of such runoff will not be less than pre-development conditions. Special emphasis shall be placed on the impacts of proposed encroachments into the required buffer.
   (5) Where the developer of property subject to the terms of this Watershed Protection Ordinance seeks to utilize existing or planned off-site storm-water quality management facilities, the developer shall provide a written certification that the owner of the off-site facilities will accept the runoff and be responsible for its

adequate treatment and that the arrangement will run with the land in a manner that will be acceptable to the Planning Board.

b. The study will make use of existing Deering Lake water quality historical data to the maximum extent possible. If new data is to be introduced, the Town reserves the right to have the data reviewed by an independent expert at the expense of the property developer.

c. The study shall be submitted to the Planning Board for review and approval concurrent with the submission of applications for review and approval of site or subdivision plans or applications for land disturbing or erosion and sediment control permits.

12.8 Buffer Requirements

a. A 75 foot wide buffer zone shall be maintained along the edge of any tributary stream discharging into Deering Lake and along the edge of any wetlands associated with those tributary streams. The required setback distance shall be measured from the centerline of such tributary stream and from the delineated edge of a wetland. Streams and wetlands shall be delineated from their mean high water mark. The buffer zone shall be maintained in its natural state to the maximum extent possible.

b. A reduction in the required buffer zone width down to an absolute minimum of fifty-feet (50') may be granted by the Planning Board upon presentation of a hydrologic or other study that provides documentation and justification, acceptable to the Planning Board, that even with the reduction, the same or a greater degree of water quality protection would be afforded as would be with the full-width buffer zone. In granting such a reduction, the Planning Board may require certain conditions of approval which may include, but are not necessarily limited to, restrictions on use or type of construction, and/or additional erosion, runoff or sedimentation control measures, as deemed necessary to protect water quality.

c. All development shall be located outside of the required buffer zone.

d. The following uses shall not be permitted within the buffer zone or within twenty-five feet (25') of any required buffer zone:

(1) septic tanks and drain-fields;

(2) feed lots or other livestock impoundments;

(3) trash containers and dumpsters which are not under roof or which are located so that leachate from the receptacle could escape unfiltered and untreated;

(4). fuel storage in excess of fifty (50) gallons [200L];

(5). sanitary landfills;

(6). activities involving the manufacture, bulk storage or any type of distribution of petroleum, chemical or asphalt products or any materials hazardous to Deering Lake (as defined in the Hazardous Materials Spills Emergency Handbook, American Waterworks Association, 1975, as revised) including specifically the following general classes of materials:

(a) oil and oil products

(b) radioactive materials

(c) any material transported in large commercial quantities that is a very soluble acid or base, highly biodegradable, or can create a severe oxygen demand

(d) biologically accumulative poisons

(e) the active ingredients of poisons that are or were ever registered in accordance with the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended (7 USC 135 et seq.)

(f) substances lethal to mammalian or aquatic life.

(g) road salt

(h) lawns

(7). No more than 50 % of basal area of timber may be cut over a twenty (20) year period.

Appendix Eleven

Perched Beaches

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
6 Hazen Drive, P.O. Box 95, Concord, NH 03302-0095
(603) 271-2457 FAX (603) 271-7894

Protect Your Lake!: Beaches and Water Quality

Many waterfront owners feel that having a beach greatly improves the value of their frontage. It provides a place to relax in the sun or play a little volleyball. Beaches provide easy access to the water for swimming and a place for the kids to play. Beaches are great, right? WRONG! Improperly constructed and maintained beaches are endangering the quality of many lakes and ponds. Beach construction damages the environment in many ways.

The first damaging factor lies in beach construction. Removal of shoreline vegetation also means removal of valuable habitat and food for a variety of wildlife, both terrestrial and aquatic. This vegetation also protects your shores from eroding. The second damaging factor is SAND. Let's face it, you can't build a beach without sand. Unfortunately, sand can both physically and chemically damage a waterbody. Sand inevitably washed from beaches with wave and ice action, and carries with it phosphate. Phosphorus feeds the growth of aquatic plants and algae. You may have noticed green "clouds" along the bottom in some areas. High concentrations of algae , which may color the water, can be considered algae blooms. The more phosphorus available, the larger the algae bloom. If phosphorus levels are high enough, the nuisance types of algae may become dominant creating undesirable scums and odors. As the algae decays, it will consume oxygen, perhaps even endangering fish survival. Physically, sand can smother bottom-dwelling organisms as well. Environmental damage aside, decreased water clarity from algae problems often results in decreased property values and increased water treatment costs.

The sand which erodes from beaches does not simply disappear. This sand is deposited by natural and man-made currents in places like boat slips, navigational channels, behind dams, and natural and man-made inlets where it may become a safety hazard. Slips become unusable without expensive and once again, environmentally damaging, maintenance dredging. Navigational channels may be choked with sand causing damage to boats which bottom out. The storage capacity of dams may be reduced, increasing the risk of flooding and decreasing valuable water supplies. Coves gradually become more and more shallow, making the shoreline inaccessible by boats. The shallower water coupled with increased nutrient levels then promotes the growth of emergent vegetation, further reducing residents' ability to use their frontages for activities like swimming.

For these reasons, the construction and replenishment of beaches requires a permit from the NH Department of Environmental Services Wetlands Bureau. New beaches must use no more than 20% of an applicant's shoreline (50 ft. Max.) and be constructed using a perched type design which has little to no slope and utilizes some form of barrier, typically the natural rock at the waterline, to reduce if not eliminate the erosion of sand into the water. Replenishment of existing beaches is limited to no more than 10 cubic yards which may be placed once every 6 years. If a beach requires sand more often, it is a good indicator that it is improperly constructed. The need for sand may be reduced by diverting surface water runoff away from the area or reducing the slope of the beach. Altering the slope will require a Wetlands permit. Failure to obtain a permit to construct or replenish a beach may result in fines between $300 and $2000 as well as required restoration.

Please help us take care of our lakes to ensure that they will provide water, recreation and wildlife habitat for many generations. For more information on proper beach construction and filing an application, please review the attached fact sheet or contact the NH Wetlands Bureau at 271-3503.

BEACH CONSTRUCTION AND MAINTENANCE

DESIGN GUIDELINES:

The design guidelines detailed below provide information which will allow you to design your project in accordance with the bureau's rules. Incorporating all of these guidelines into your design, plans, and application materials will increase the likelihood of receiving a permit.

SITE SELECTION:

The beach needs to be placed in the least environmentally impacting location on the frontage. When selecting an appropriate location look for a position which requires the least amount of tree and vegetation removal and the least amount of rock and earth removal preferably in an area where the slope is naturally more flat. The beach should be positioned in an area where the swimming is not mucky and where there is little aquatic weed growth since the bureau rarely allows dredging of the lake bottom or placement of sand in the water for beach construction. Beaches may not be constructed in wetland areas.

BEACH CONFIGURATION AND LOCATION:

Current policy requires that new beaches be "perched". A perched beach is located entirely out of the water above the existing undisturbed natural bank and has little or no slope. All sand must be placed out of the water and above the high water mark. The objective of constructing perched beaches is to insure that sand does not erode into the water over time. In the long run this is better for both the environment and the homeowner since such beaches require less maintenance.

Preferably the beach should be constructed in a manner which leaves any naturally existing boulders on the shoreline in their existing location. If the frontage is not naturally rocky, rocks should be placed along the lakeward side to separate the perched beach area from the water. If excavation into the bank is required then an acceptable method of stabilizing the landward side of the cut must be incorporated. Many designs propose to stabilize this landward side with a stone retaining wall.

A beach, as with all shoreline structures, must be located at least 20 feet from each of the property boundaries. The project should be designed so that construction activities required for beach construction are also located at least 20 feet from the boundary.

SIZE:

Most beaches may be no larger than 20 percent of the entire contiguous frontage up to a maximum of 50 linear feet and cannot alter more than 900 square feet of total area. Beaches larger than this are considered major impact projects and must have a demonstrated need to be larger for the bureau to consider approving them.

ACCESS TO WATER FROM BEACH:

Steps leading to the water from the beach may be included in the design but should be constructed so that they are cut back into the bank rather than extending out into the lake. Step width should generally be kept to less than 4 feet.

SURFACE WATER DIVERSION:

Beach projects must incorporate methods for diverting surface runoff around the beach area. Such diversion helps to eliminate erosion of the sand into the lake during storm events. Many beach designs incorporate a shallow grass or stone lined swale around the landward most periphery of the beach.

CONSTRUCTION MATERIALS AND CONSTRUCTION GUIDELINES:

Any sand placed in the beach area must be clean. Clean sand is sand which contains little or no silt or loam which can cause water quality problems if it enters the lake. No more than 10 cubic yards of sand may be used.

Construction should be planned to take place during the lake drawdown if possible. If this is not possible the work should scheduled for when the lake is at its lowest level. Appropriate siltation controls need to be installed prior to the commencement of construction and maintained until all disturbed areas are stabilized. Machinery should not be entering the water during construction.

BEACH REPLENISHMENT:

Beach sand replenishment is permissible only once every six years and in general may not exceed more than 10 cubic yards. Sand is no longer allowed to be placed below the high water mark even on previously permitted or grandfathered beaches. Applications for beach replenishment must also incorporate methods for diverting surface runoff around the beach area.

BEACH CONSTRUCTION AND MAINTENANCE

PROJECT CLASSIFICATION:

Use the chart below to determine the classification of your project.

Your project is **MAJOR** if...	the beach construction or replenishment project: 1. Is NOT for a privately owned single family residence; or 2. Requires dredge or fill below the high water line; or 3. Involves more than 900 square feet of dredge or fill; or 4. Is located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; or 5. Alters more than 20 percent of frontage (or more than 50 foot); or 6. Involves placement of more than 20 cubic yards of sand; or 7. Requires replenishment more than once during a 6 year period.
	the project involves work in or adjacent to prime wetlands
	it involves work in an area identified as an exemplary natural community and/or has documented occurrences of state or federally listed Endangered or Threatenend species
	it requires removal of more than 20 cubic yards of material from public waters
Your project is **MINOR** if...	the beach construction or replenishment project: 1. Is for a privately owned single family residence; and 2. Requires no dredge or fill below the high water line; and 3. Involves no more than 900 square feet of dredge or fill; and 4. Is not located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; and 5. Alters no more than 20 percent of frontage (50 foot maximum); and 6. Involves placement of between 10 and 20 cubic yards of sand
	it requires removal of less than 20 cubic yards of material from public waters and is not otherwise major
	it involves removal of emergent or submergent vegetation requiring disturbance of the bottom sediments and is not otherwise major. See minimum below for projects involving control of exotic aquatic weeds Cabomba carolina (fanwort) and/or Myrophyllum heterophyllum (exotic milfoil).
Your project is **MINIMUM** if...	the beach construction or replenishment project: 1. Is for a privately owned single family residence; and 2. Requires no dredge or fill below the high water line; and 3. Involves no more than 900 square feet of dredge or fill; and 4. Is not located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; and 5. Alters no more than 20 percent of frontage (50 foot maximum); and 6. Involves placement of 10 cubic yards of sand or less; and 7. Requires replenishment once during a 6 year period.
	it involves cutting of aquatic weeds above the roots provided that: 1. there is no disturbance of the bottom sediments; and 2. it is not in prime wetlands, marshes, bogs and does not impact an exemplary natural community or endangered or threatened species.
No permit is required if...	it involves control of exotic aquatic weeds Cabomba carolina (fanwort) and/or Myrophyllum heterophyllum (exotic milfoil) as authorized by RSA 487:17, provided: 1. work is conducted under the supervision of DES; and 2. is not in or adjacent to prime wetlands, marshes, bogs, and does not impact an exemplary natural community or endangered or threatened species.
	it involves hand raking of leaves or other organic debris from the shoreline or lakebed provided that: 1. At the time the raking is done, the area raked is exposed by drawdown; or 2. Raking does not disturb vegetative roots and is limited to 900 square feet of area.

BEACH CONSTRUCTION AND MAINTENANCE

PLAN CRITERIA:

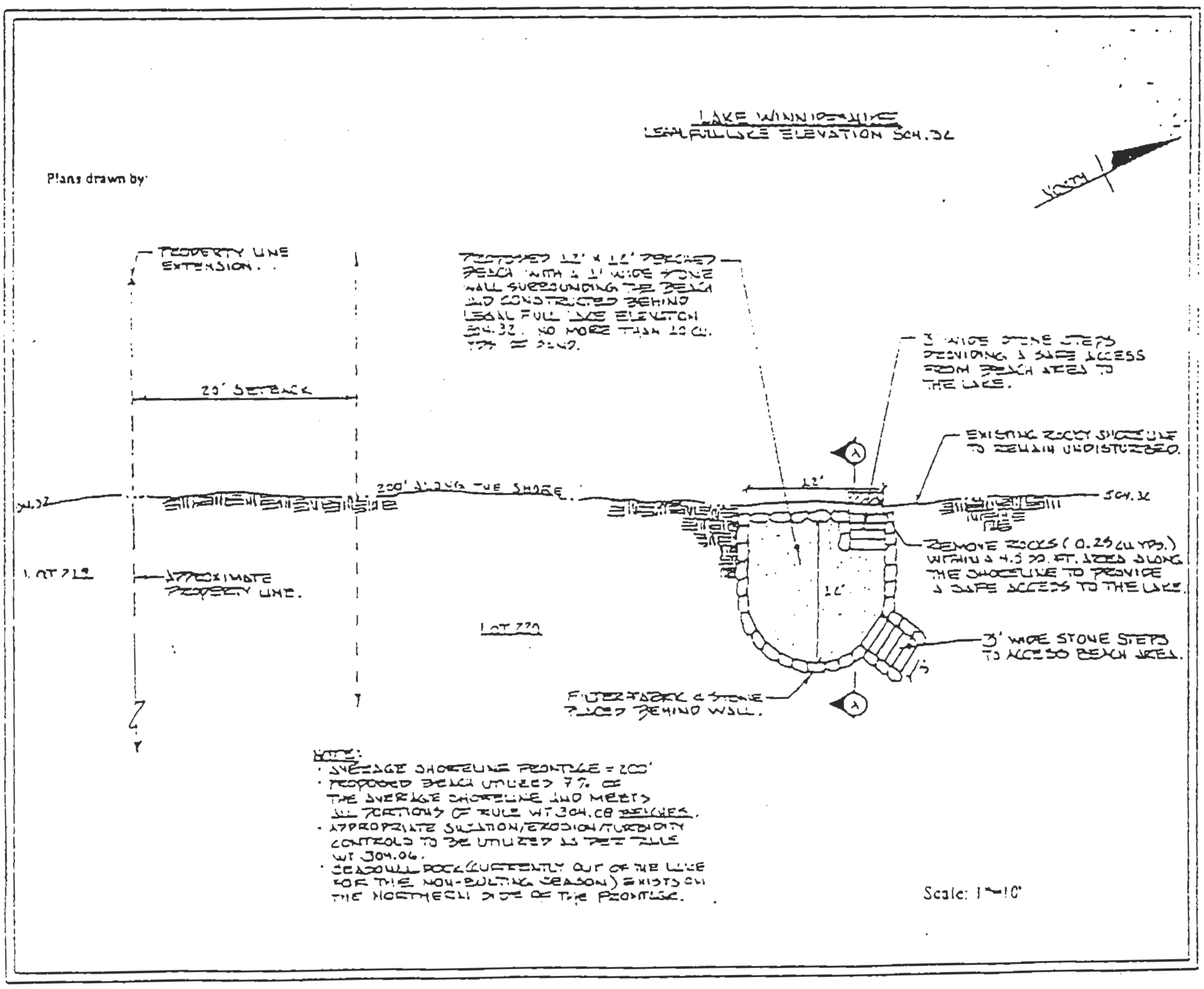
Applications for beach construction must include two different views of the project: a "plan view plan" and a "cross-sectional plan". Examples of each of these plans are shown below. Both plans must clearly show that the design considerations and criteria for beach construction described in earlier sections of this document have been incorporated into the design.

PLAN VIEW:

A "plan view" plan can be visualized as drawing a plan as if you were looking down on the land from an airplane. This plan must show the following information:

- ☐ The entire frontage of the parcel in question accurately depicting the shape or contour of the frontage;
- ☐ The linear feet of the shoreline frontage;
- ☐ The location and aerial dimensions of the proposed beach area (and access steps if applicable);
- ☐ The distance from the edges of the proposed beach area to each abutting property boundary;
- ☐ The location and aerial dimensions (ex. length and width) of all other existing structures on the frontage;
- ☐ An arrow showing the direction north;
- ☐ The scale of the plan (ex. 1"=20');
- ☐ Notes indicating how much sand is proposed to be placed and that it is not to be placed in the water;
- ☐ Notes indicating the proposed sequence of construction activities;
- ☐ The location and diameter of any trees which need to be removed as part of the beach construction.

SAMPLE PLAN VIEW:



BEACH CONSTRUCTION AND MAINTENANCE

PLAN CRITERIA:

Cross-Sectional View:

- ☐ A "cross-sectional view" can be visualized as drawing a plan as if you were looking at a vertical slice through the bank. This plan must show the following information:
- ☐ The slope of the existing bank;
- ☐ The proposed slope after the beach has been constructed;
- ☐ The location of the high water mark in relation to the proposed beach;
- ☐ The vertical distance between the high water mark and the perched beach;
- ☐ The method by which the sand will be separated from the water (ex. natural undisturbed boulders, placed boulders, etc.);
- ☐ The method by which the landward side of the beach will be stabilized (ex. retaining wall, etc.);
- ☐ The scale of the plan (ex. 1"=20').

SAMPLE CROSS-SECTIONAL PLAN VIEW: